Trends and Correlates of Physical Activity and Sedentary Behaviour in the Thai Population

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Abstract

To facilitate the development of effective public health programs and policies to increase physical activity (PA) and reduce sedentary behaviour (SB) in Thailand, there is a need for comprehensive epidemiological evidence and a sound assessment of prevalence, trends, and factors associated with these behaviours. This PhD research therefore aimed to: 1) identify gaps in the available literature on PA and SB in Thailand; 2) determine the prevalence of PA and SB among Thai adults using the validated Global Physical Activity Questionnaire (GPAQ); 3) summarise evidence on individual, social, environmental, and policy correlates of PA and SB in the Thai population; 4) develop criteria to classify the International Classification of Activities for Time-Use Statistics (ICATUS) activities into sleep, SB, light-intensity PA, and moderate-to-vigorous PA categories, based on expert assessment; and 5) establish trends in PA and SB and assess how correlates of these behaviours have changed among Thai adults over 15 years.

To achieve the first aim, we conducted a systematic scoping review according to the Guidance for Conducting Systematic Scoping Reviews. To achieve the second aim, we conducted a secondary analysis of population-representative data from a Thai national survey. To achieve the third aim, we conducted a systematic review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. To achieve the fourth aim, we conducted a Delphi study including 13 content experts. To achieve the fifth aim, trends and sociodemographic correlates of PA and SB in Thailand were examined using Thai national ICATUS-based surveys. Using time-use data from ICATUS allowed for treating PA and SB estimates as integrative parts of a time-use composition, to examine the new holistic 24-hour movement guidelines.Overall, Study 1 found that the interest in research on PA and SB in Thailand has grown in the past two decades. Major research gaps were found for measures and methodology used in previous studies and only limited evidence was found on SB. Findings from Study 2 show low prevalence of PA among Thai adults in 2015 and a declining trend in the prevalence of meeting the PA recommendation since 2004. A range of sociodemographic correlates of PA and SB in the Thai population were identified in Study 3. Study 5 found that more than half of Thai adults engaged in prolonged sitting over a 15-year period. These findings highlight the need of public health programs to promote PA and reduce SB in Thailand. Future interventions and policies to increase PA participation should focus particularly on girls, older women, young adults, urban residents, and those with low education. The interventions to improve self-efficacy for PA and lower perceived barriers for PA should be implemented among all agegroups. Future interventions to reduce SB are also needed among adults, particularly for males, older age groups, obese, and those with higher education. However, more studies are needed to provide a more complete picture of what

factors are influencing PA and SB in the population; particularly among children, adolescents, older adults and at social, environmental and policy levels.

Student Declaration

"I, Nucharapon Liangruenrom, declare that the PhD thesis by Publication entitled "Trends and Correlates of Physical Activity and Sedentary Behaviour in the Thai Population" is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work".

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Details of Included Papers: Thesis by Publication

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Item/ Chapter No.	Paper Title	Publication Status (e.g. published, accepted for publication, to be revised and resubmitted, currently under review, unsubmitted but proposed to be submitted)	Publication Title and Details (e.g. date published, impact factor etc.)
4	Physical Activity and Sedentary Behaviour Research in Thailand: a Systematic Scoping Review	Published	Published in May 2018 in BMC Public Health (Q1; 5-year IF = 3.039, SNIP = 1.268)
5	Do Thai People Meet Recommended Physical Activity Level?: the 2015 National Health and Welfare Survey	Published	Published in June 2017 in the Journal of Health Systems Research (IF = 0.169)
6	Correlates of Physical Activity and Sedentary Behaviour in the Thai Population: a Systematic Review	Published	Published in April 2019 in BMC Public Health (Q1; 5-year IF = 3.039, SNIP = 1.268)
7	Standardised criteria for classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity categories	Published	Published in November 2019 in the International Journal of Behavioral Nutrition and Physical Activity (Q1; IF = 5.55; SNIP = 2.14)
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Declaration by [candidate name]: Nucharapon Liangruenrom

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List of abbreviations

AHTUS : American Heritage Time Use Study

ATUS : American Time Use Study

BMI : Body Mass Index

BRFSS : Behavioral Risk Factor Surveillance System

CODA : Compositional Data Analysis

CPS : Current Population Survey

DLW : Doubly Labelled Water

GDP : Gross Domestic Product

GHO : Global Health Observatory

GoPA : Global Observatory for Physical Activity

GPAQ : Global Physical Activity Questionnaire

GSLTPAQ : Godin-Shephard Leisure-Time Physical Activity Questionnaire

GSS-TU : Statistics Canada's General Social Survey – Time Use

HBSC : Health Behaviour in School-aged Children

HETUS : Harmonised European Time Use Survey

HSRI : Health Systems Research Institute

HWS : Health and Welfare Survey

ICATUS : International Classification of Activities for Time-Use Statistics

IPAQ : International Physical Activity Questionnaire

ISCO : International Standard Classification of Occupations

LPA : Light-intensity Physical Activity

MAQA : Modifiable Activity Questionnaire for Adolescents

MET : Metabolic Equivalent of Task

MPA : Moderate-intensity Physical Activity

MTUS : Multinational Time Use Study

MVPA : Moderate-to-Vigorous Physical Activity

NCDs : Non-Communicable Diseases

NDLTD : Networked Digital Library of Theses and Dissertations

NHANES : National Health and Nutrition Examination Survey

NHES : National Health Examination Survey

NHIS : National Health Interview Survey

NOS : Newcastle-Ottawa Scale

NSO : National Statistical Office

PA : Physical Activity

PARC : Physical Activity Research Center

PBEPAS : Perceived Benefits to Physical Activity Scale

PRISMA : Preferred Reporting Items for Systematic reviews and Meta-Analyses

SB : Sedentary Behaviour

STAR : Space-Time Activity Research

TOPAQ : Tecumseh Occupational Physical Activity Questionnaire

TRF : Thailand Research Fund

UNSD : United Nations Statistics Division

VIRTUE : Viable Integrative Research in Time-Use Epidemiology

VPA : Vigorous-intensity Physical Activity

WHO : World Health Organization

YRBS : Youth Risk Behaviour Survey

CHAPTER I: Introduction

Non-communicable Diseases – Global Health Agenda

Non-communicable diseases (NCDs) have now become a leading cause of mortality worldwide, outranking infectious diseases (World Health Organization, 2013). NCDs, which mostly commonly include cardiovascular diseases, cancers, chronic lung diseases, and diabetes, account for 36 million deaths and 14 million premature deaths each year (World Health Organization, 2013). The mortality rate caused by NCDs is increasing faster in low- and middle-income countries, but their impact is high worldwide. In high-income countries, the percentage of deaths caused by NCDs is substantial and remained unchanged at 87% from 2000 to 2016, whilst in low- and middle-income countries, the percentage of deaths in this period increased from 55% to 68% (The World Bank, 2019). This NCD epidemic poses significant challenges that touch upon the whole global performance, not only health-related impacts. The economic consequences associated with NCDs have been estimated at US$ 47 trillion loss of global gross domestic product (GDP) from 2011 to 2025 (Bloom et al., 2012). From a societal perspective, evidence confirms that NCDs have contributed to inequalities in income, socioeconomic, and education status (Niessen et al., 2018). The magnitude of losses on the overall economic growth and sustainable development owing to NCDs is immense and needs immediate action.

Most NCDs are preventable, and thus manageable. However, the total burden of NCDs is rising both in terms of their contribution to the overall mortality and morbidity (Bloom et al., 2012; Niessen et al., 2018; The World Bank, 2019; World Health Organization, 2013). With the high impact of these diseases, the prevention of NCDs is a priority at the global political level. Addressing NCDs was the second health agenda after HIV/AIDS that the United Nations General Assembly adopted at the Political Declaration of the High-level Meeting of the United Nations General Assembly on the Prevention and Control of NCDs in 2011 (World Health Organization, 2013). Following the Declaration, the World Health Organization (WHO) developed the NCD Global Monitoring Framework to track the progress and report on the attainment of nine voluntary global targets for NCDs to be achieved by 2025 (World Health Organization, 2013). Later in 2013, the World Health Assembly endorsed the WHO Global Action Plan for the Prevention and Control of NCDs 2013 – 2020 providing guidelines and policy options to attain the nine targets (World Health Organization, 2013). Tackling NCDs has become the global commitment that needs to be addressed at national, regional, and global levels. The burden of NCDs, such as diabetes, chronic respiratory diseases, cardiovascular diseases, and cancers, is largely attributable to behavioural risk factors including, but not limited to, tobacco use, alcohol consumption, poor nutrition, and physical inactivity (World

Health Organization, 2013). Global targets and strategies to prevent and control NCDs have, therefore, been focusing on improving these four behaviours.

Physical Activity – the ‘Best Buy’ in Public Health

PA has gained attention as one of the ‘best buys’ in public health to maintain and improve general health and reduce NCD risks (Morris, 1994). PA is defined by the WHO as any bodily movement produced by skeletal muscles that requires energy expenditure (World Health Organization, 2010). PA can be performed in a variety of ways not limited to exercise and/or sports (Caspersen, Powell, & Christenson, 1985; World Health Organization, 2010, 2018). PA involves any activity that results in energy expenditure ranging from low to high intensity and can be undertaken in different ways and for different purposes such as cycling to work, and walking to a supermarket (Caspersen et al., 1985; World Health Organization, 2010, 2018).

A large body of evidence has shown the beneficial effects of PA on health, especially on the primary and secondary prevention of NCDs. Strong evidence supports the effect of regular Moderate-to-Vigorous PA (MVPA) on the reduction of the incidence of many chronic diseases such as cardiovascular disease, coronary heart disease, colon cancer, type II diabetes mellitus, blood pressure, obesity, depression and osteoporosis (Kesaniemi et al., 2001; Warburton, Nicol, & Bredin, 2006; World Health Organization, 2018). Physical inactivity is one of the ten leading risk factors for global mortality, and it causes approximately 3.2 million deaths per year (Lim et al., 2012; World Health Organization, 2014). The effects of physical inactivity on the incidence of major NCDs and mortality rates are considerable, but potentially avoidable. It is estimated that 6%-10% of NCD deaths worldwide could be prevented by increasing physical activity (PA) participation (Lee et al., 2012). Increasing PA would reduce healthcare costs and also lead to economic growth due to reductions in treatment costs and lost productivity from premature deaths.

Besides its positive impact on physical health, PA can also help improve mental health and well-being in a population. Along with the global recognition of growing burden caused by NCDs, mental health has also become the global issue of importance in the twenty-first century (Rehm & Shield, 2019). Mental illnesses were estimated to affect more than 1 billion people worldwide in 2016 (Rehm & Shield, 2019). Promotion of mental health and well-being has been adopted as one of the Sustainable Development Goals (SDGs) to be achieved by 2030 (United Nations, 2015). A large body of literature has shown psychological benefits of PA, participation in PA is, therefore, one of the key strategies recommended for people diagnosed with poor mental health (Peluso & Andrade, 2005; Rehm & Shield, 2019; Stanton, Happell, & Reaburn, 2014).

PA intensity is commonly described by energy expenditure using metabolic equivalent of task (MET) where 1 MET is the rate of energy expenditure while sitting at rest (U.S. Department of Health and Human Services, 2018; World Health Organization, 2010). PA is classified by intensity into three levels; i) Light-intensity PA (LPA) is defined as any non-sedentary waking activity with less than 3 METs such as standing, slow walking, or watering plants; ii) Moderate-intensity PA (MPA) is defined as any activity that requires energy expenditure of 3 to less than 6 METs, for example, walking for exercise, yard work, or washing clothes by hand; and iii) Vigorous-intensity PA (VPA) is defined as any activity with energy expenditure of 6 or more METs such as running, Muay Thai boxing, or skiing (Ainsworth et al., 2011; U.S. Department of Health and Human Services, 2018; World Health Organization, 2010).

Given the public health significance of PA, the WHO developed recommendations on PA for health to provide guidelines of the frequency, duration, intensity, type and total amount of PA necessary for NCD prevention and control (World Health Organization, 2010). In brief, the recommendations are provided for three different age groups. It is recommended that ; i) children and young people (5-17 years old) do at least 60 minutes of MVPA daily; ii) adults (18-64 years old) and iii) older adults (65 years old and above) do at least 150 minutes of MPA or 75 minutes of VPA or any equivalent combination of MVPA per week (World Health Organization, 2010). These universal recommendations have been used as a surveillance and monitoring tool to track progress and inform policies on PA promotion at national, regional and international levels.

While following these guidelines may help maintain overall health, different types of PA also have complementary benefits. Moreover, there are growing evidence showing higher levels of muscle-strengthening exercise are associated with a reduced mortality risk (Katzmarzyk & Craig, 2002; Metter, Talbot, Schrager, & Conwit, 2002; Warburton, Gledhill, & Quinney, 2001). Some guidelines, therefore, include a recommendation on muscle strengthening activities such as weight lifting and resistance training for each age group. For example, according to the WHO recommendations, children and young people are recommended to engage in vigorous activity, including activities to strengthen muscles and bones, at least three times a week, while adults and older adults two or more days per week (World Health Organization, 2010).

Sedentary Behaviour – a New Challenge in the Modern World

Sedentary behaviour (SB) can be operationally defined as sitting or reclining with very low energy expenditure (Mark S. Tremblay et al., 2017). Prolonged SB has been linked to health risks (Biswas et al., 2015; de Rezende, Lopes, Rey-Lopez, Matsudo, & do Carmo Luiz, 2014; Proper, Singh, Van Mechelen, & Chinapaw, 2011). The term 'SB' might be used as an equivalent of 'physical inactivity'; however, there is a clear distinction between them (Mark S. Tremblay et al., 2017). SB refers to any waking activity with an energy expenditure of 1.5 or less METs while in a sitting, reclining or lying position (Mansoubi et al., 2015; Mark S. Tremblay et al., 2017). The posture and energy expenditure are two important combined components distinguishing SB from physical inactivity. As mentioned above, physical inactivity refers to insufficient PA, a lack of MVPA, or not meeting PA levels recommended in the present global guidelines (Mansoubi et al., 2015; Mark S. Tremblay et al., 2017; World Health Organization, 2010). However, an absence of PA cannot be implied or categorised as SB (Mansoubi et al., 2015; Mark S. Tremblay et al., 2017). In addition, SB can co-exist with physical inactivity and PA at different levels. Figure 1 shows SB and PA as distinct constructs (Saunders, Chaput, & Tremblay, 2014).

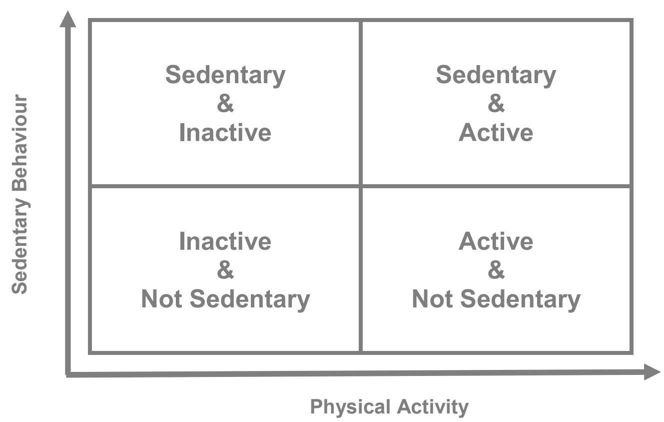

Figure 1. 1 Sedentary behaviour and physical activity as distinct constructs (adapted from Saunders et al., (2014))

Figure 1.1 classifies individuals into four categories: i) individuals who sit for a long period of time and do not spend enough time in PA (sedentary, inactive); ii) individuals who spend too much time sitting, but also spend sufficient amount of time participating in PA (sedentary, active); iii); individuals who are not sedentary and not meeting the recommended MVPA levels (inactive, not sedentary); and iv) individuals who are sufficiently active and do not spend too much time sitting (active, not sedentary) (Saunders et al., 2014). The category IV is an ideal group for which all PA/SB interventions aim, while category I represents the situation which most countries are encountering.

SB is a young but progressive area that emerged in public health, physiology, behavioural epidemiology, and population research around two decades ago (Owen, Healy, Matthews, & Dunstan, 2010; Pedišić, Dumuid, & S Olds, 2017). SB is evolving as a new challenge for PA and health research (Owen et al., 2010). Evidence on health outcomes associated with sitting can be traced to 1950s when PA epidemiology started developing (Pedišić et al., 2017). In a classic study, Morris and colleagues found greater rates of cardiovascular disease among sedentary bus drivers than that of active bus conductors (Morris, Heady, Raffle, Roberts, & Parks, 1953). From this work, PA and physical inactivity were highlighted as a potential contributor to cardiovascular health (Morris et al., 1953). Later in 1985, literature on the negative health outcomes of television viewing, one of the common sedentary activities, was published in relation to obesity in children and adolescents (Biddle, Bengoechea, & Wiesner, 2017; Dietz & Gortmaker, 1985). Research on health risks of SB have received a greater amount of attention and developed rapidly since the mid-2000s (Biddle et al., 2017; Owen et al., 2010).

A substantial amount of evidence on the negative health consequences of SB emerged. Previous studies found that SB was associated with increased risk of all-cause mortality, premature deaths, and some major NCD incidence such as cardiovascular disease, diabetes, and cancers (Biswas et al., 2015; Dunstan, Howard, Healy, & Owen, 2012; Jalayondeja et al., 2017; Owen et al., 2010; Wilmot et al., 2012). Although SB has been shown to be associated with deleterious health outcomes even when statistically adjusting for MVPA, some studies suggested that adverse health outcomes of SB are attenuated at high levels of MVPA (Biddle et al., 2017; Biddle et al., 2019; Biswas et al., 2015; Ekelund et al., 2016; Owen et al., 2010). It may, therefore, be imperative that effective public health programs and policies need to focus not only on increasing population levels of PA, but also reducing time spent in SB. People are exposed to common SB such as using computer at work, television watching on portable devices, and sitting in automobiles. Evidence from studies that assessed time use using accelerometers shows that adults spend more than half of waking hours (9.3 hours per day) in sedentary activities and only 4% - 5% or 0.7 hours per day in MVPA (Healy et al., 2007). Time spent in screen-based sedentary activities of more than two hours a day was negatively associated with MVPA participation among adolescents from 39 countries in Europe and North America (Melkevik, Torsheim, Iannotti, & Wold, 2010). Time spent in SB is associated with lower overall energy expenditure in PA (Owen et al., 2010). Initiatives or settings that encourage reductions of SB may help increase the time spent in LPA and/or MVPA. Insufficient PA and extensive or prolonged SB should, therefore, be addressed as a serious and maturing public health priority in all high-income, middle-income, and low-income countries.

Trends of Physical Activity and Sedentary Behaviour in Adult Populations

A recent study established worldwide trends in insufficient PA of nearly 2 million participants from 168 countries (representing 96% of the global population) and found that 27.5% or more than 1.4 billion adults were not physically active enough, according to the WHO recommendations on PA (Guthold, Stevens, Riley, & Bull, 2018). A higher percentage of insufficient PA was found in high-income Western countries (36.8%), high-income Asian Pacific (35.7%), Latin America and Caribbean (39.1%), and South Asian (33.0%) countries (Guthold et al., 2018). The prevalence of insufficient PA varied across countries, regions, and income groups from less than 10% in some countries to more than 50% in others (Guthold et al., 2018). Despite health benefits of PA, the prevalence of physical inactivity (or not meeting the WHO recommendations on PA) in most parts of the world remained high and generally unchanged from 2001 to 2016 (Guthold et al., 2018). However, trends in PA and SB vary across countries. This suggests that country-specific studies on trends of PA and SB are warranted.

According to current worldwide trends in physical inactivity, the global progress towards achieving one of the nine NCD targets – a 10% relative reduction in the prevalence of insufficient PA by 2025, has been slow (Guthold et al., 2018; World Health Organization, 2014, 2018). A low level of PA participation may be explained by the combined impacts of increased urbanisation and industrialisation (Hallal et al., 2012), which reflects on demographic, behavioural, social, environmental, technological and other changes in our ways of living. These transitions tend to change people's behaviours towards sedentary lifestyles, as also shown in a multinational time-use study, where sedentary time increased and active time decreased in adult populations from the United States, the United Kingdom, China, Brazil, and India (Ng & Popkin, 2012). Total sitting, as well as leisure and occupational sedentary time among adults also increased over recent decades in several countries (Aadahl et al., 2013; Bauman et al., 2011; Chau et al., 2012; Church et al., 2011).

Correlates of Physical Activity and Sedentary Behaviour in Adult Populations

Several studies have examined factors influencing adult participation in PA and SB. Many of them found that male sex and younger age were two consistent sociodemographic correlates of high PA and low SB (Bauman et al., 2012; O'donoghue et al., 2016; Trost, Owen, Bauman, Sallis, & Brown, 2002). Perceived self-efficacy and self-reported health status were also two strong individual-level factors contributing to more PA participation in adults (Bauman et al., 2012; Trost et al., 2002). Preliminary evidence relating to social and environmental factors, although limited, showed positive associations between social support, especially from friends and family and access to facilities and adults' PA level (Bauman et al., 2012; Trost et al., 2002). Much less evidence and inconsistent findings were found for associaions between social and environmental factors and SB, and the associations seems to depend on the type of SB (O'donoghue et al., 2016).

Time-use Epidemiology – a New Approach to Physical Activity, Sedentary Behaviour, and Sleep Research

To date, a wealth of evidence has examined relationships of PA and SB with health indicators, without considering other movement and non-movement behaviours such as sleep. Recent studies have also suggested that times spent in movement and non-movement behaviours (e.g., sleep, SB, quiet standing, LPA, MPA, and VPA) are parts of a time-use composition (Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015; Dumuid et al., 2018; Pedišić, 2014; Pedišić et al., 2017). Assessing PA and SB in isolation, without considering other relative movement and non-movement behaviours, may yield inconsistent and incorrect estimates. That is, everyone has no more and no less than 24 hours available in a day, and this fixed time period is relatively spent in any movement and/or non-movement behaviours. When analysing one or more of these behaviours, it is important that the remaining behaviours are taken into account, because a change in time spent in one behaviour will inevitably affect time spent in at least one of the other remaining behaviours (Chastin et al., 2015; Dumuid et al., 2018; Pedišić, 2014; Pedišić et al., 2017).

In a recently developed framework for Viable Integrative Research in Time-use Epidemiology (VIRTUE framework), it is suggested that PA, SB, and sleep should be analysed as integrative parts of a 24-hour day (Pedišić et al., 2017). Given emerging evidence and properties of the behaviours, new public health guidelines combining recommendations for PA, SB, and sleep across 24 hours have been introduced. These new 24-hour guidelines have recently been adopted in some countries such as Canada, Australia, New Zealand, and Thailand (Khamput et al., 2017; New Zealand Ministry of Health, 2017; Okely et al., 2017; Tremblay et al., 2016; Mark S Tremblay et al., 2017).

Thailand – Current Situation and Overview

In 2012, nearly three quarters of all physical inactivity-related deaths occurred in low- and middle-income countries (World Health Organization, 2014). However, even with this high magnitude of the problem, research on NCDs and health behaviours is less developed in these countries, including Thailand, compared to countries with a better economic status. Physical inactivity was among the top 15 risk factors that caused the most disease burden in Thailand in 2010 (Institute for Health Metrics and Evaluation, 2010). About 3% of premature mortality and disability accounted for cardio and circulatory diseases, diabetes, and cancers attributable to physical inactivity (Institute for Health Metrics and Evaluation, 2010).

Thai people spent approximately 2 hours participating in PA and 13 hours sitting per day in 2015 (Thai Health Foundation, 2015; Thanamee et al., 2017). This puts Thailand into the second category according to Saunders' constructs 'sedentary, active' or known as an 'active couch potatoes' (Owen et al., 2010; Saunders et al., 2014). Thailand aims to achieve the global target of a 10% relative reduction in physical inactivity. To meet this target, the prevalence of inactivity in the population needs to reduce from 18% of the baseline prevalence of physical inactivity in 2008 to 16% by 2025 (Topothai, Chandrasiri, Liangruenrom, & Tangcharoensathien, 2016). However, according to the Thai national surveys conducted between 2003 and 2015, the prevalence of physical inactivity was lowest around 8% - 9% in 2005 and 2007. Besides these two years, the level of inactivity was increased to around 15% - 25% (Division of Physical Activity & Health, 2015). Until 2012, the level went up to more than 33% and remained high until the last survey year in 2015 (Division of Physical Activity & Health, 2015). In addition, from the most recent prevalence report of PA and SB among Thai young people, Thailand's 2018 report card found only 26% of children and adolescents aged 6-17 years old had sufficient PA level of at least 60 minutes of MVPA per day (Active Healthy Kids Global Alliance, 2018). Although, the prevalence had increased from the 2016 report (23%), the PA level of Thai young people is concerning (Active Healthy Kids Global Alliance, 2018; Amornsriwatanakul et al., 2016). The same report found that more than 74% of Thai children and youths engaged in recreational screen time more than 2 hours per day, which was slightly lower than that of the 2016 report (78%) (Active Healthy Kids Global Alliance, 2018; Amornsriwatanakul et al., 2016).

It is evident that as a country moves to a higher development status, public health challenges of physical inactivity and SB grow in momentum. Within the last 60 years, Thailand has experienced major transformations from agriculture to industry based development. Thailand is an agriculturally based country and 49% of its labour force is employed in agriculture (Leturque & Wiggins, 2010). However, this figure has dropped from 70% in 1980 (Leturque & Wiggins, 2010). Thailand's economy grew fast during the years 1960 to 1996, particularly in 1980s (World Bank Group, 2018). Its economic progress has remarkably improved, moving from low-income to upper-middle-income status in 2011 (World Bank Group, 2018). Thailand is the second-largest economy in Southeast Asia and now has a National Strategy for attaining a high-income status within 20 years (2017-2036) (Phoonphongphiphat, 2017; World Bank Group, 2018). Thailand is also considered as a newly industrialised country, as it transitions to an industry oriented economy. Thailand shifted from 'agriculture' to 'light industry' dominated country as manufacturing of light productions such as processed foods and textiles grew (Phoonphongphiphat, 2017; Thailand Today, 2017). Thailand's economy is now driven by 'heavy industry', mainly exporting automobiles and parts, computers, and electrical appliances (Phoonphongphiphat, 2017; Thailand Today, 2017). The economic path forward that Thailand is moving to for the next 20 years will focus on high-tech industry and innovation (Phoonphongphiphat, 2017; Thailand Today, 2017).

It is not surprising that gains in economic development have led to shifts in multiple dimensions and consequences for its citizens. Urbanisation is one of the key consequences that has led to the high impact of NCDs in Thailand. From an agrarian to industrialised society, Thailand's workforce has moved away from rural work to industrial labour (Leturque & Wiggins, 2010). More than half of the total population (53.6%) is now living in urban areas where factories and manufactures are housed and this figure has increased from 35% in 1955 (Worldometers, 2017). The emerging urbanisation has changed the environments in which Thai people live and inevitably resulted in their behaviour transitions. The negative effect of urbanisation and its links to behaviour changes are key drivers of NCD pandemics in low- and middle-income countries including Thailand (The Lancet Diabetes Endocrinology, 2017).

Promotion of Active Lifestyles in Thailand

Thailand, like many other countries, has taken action and moved their health agenda determinedly. Thailand's approach, 'Triangle that Moves the Mountain' is a well-known strategy that seeks to solve complex and very difficult problems (metaphorical meaning of a mountain), including health issues (Wasi, 2000). The triangle shown in Figure 1.2 consists of i) Creation of relevant knowledge through research; ii) Social movement and participation; and iii) Political involvement and policy advocacy (Wasi, 2000). It is a synergy model in that the combined effects of the whole is greater than the summation of its parts. Research alone cannot make enough impact to initiate action and implement evidence-based health development in a country without social and political commitment. The reform of Thai health systems is one of the successes from this approach (Wasi, 2000). For example, the Health Systems Research Institute (HSRI) was established in 1992 as a coordinator for mobilising health system reforms in Thailand. The Institute has generated health system knowledge to enable research to inform the development of a national health policy. With the Minister of Public Health as its chairperson, HSRI has a direct channel to the Cabinet (Wasi, 2000).

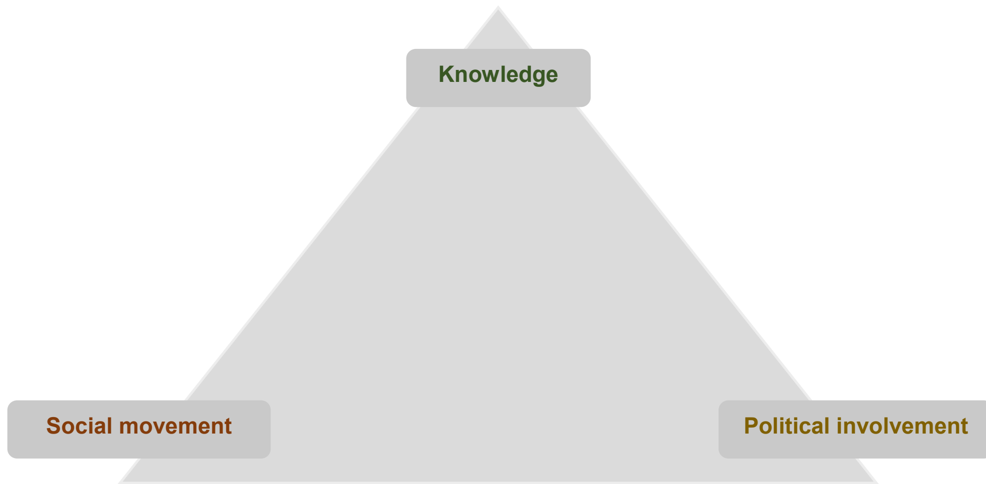

Figure 1. 2 Triangle that moves the mountain (adapted from Prawese Wasi (2000))

The promotion of PA in Thailand has now been driven by this ‘triangle’ model after it was promoted under the umbrella of NCD prevention, but mostly dominated by the other health behaviours, such as tobacco, and alcohol consumption (Topothai et al., 2016). To move the mountain (the pandemic of insufficient PA and high SB), this agenda needed more commitments from the whole society, and not only the health sector. Therefore, the triangle for PA promotion has been established for collaborative work among i) academic sector (representing ‘knowledge’) which includes research centres, institutes, and universities, for example, Physical Activity Research Center (PARC), HSRI, and Thailand Research Fund (TRF); ii) civil society sector (representing ‘social movement’) which includes associations, private organisations and club networks such as professional network of architects and town planners, Thailand Walking and Cycling Institute Foundation, and Thai Cycling for Health Association; and iii) public sector (representing ‘policy involvement’) which includes government agencies such as Thai Health Promotion Foundation (ThaiHealth), Department of Health, Ministry of Public Health, Ministry of Education, Ministry of Tourism and Sports, National Health Security Office, Department of Local Administration, Ministry of Interior, and Ministry of Transport (10th National Health Assembly, 2017).

Thailand’s efforts on improving PA and SB have made significant progress, especially at the policy level. For example, the recent development of the 1st Thai National Strategic Plan on Promotion of Physical Activity (2018-2030), which aims to improve PA and SB for people at all age groups through conducive environments and availability of support system for PA and SB (Division of Physical Activity & Health, 2018). Thailand was also part of the international movement to increase investments in the policy implementation on PA promotion agreed in the Bangkok Declaration on Physical Activity for Global Health and Sustainable Development (10th National Health Assembly, 2017; Topothai et al., 2016). At the agency level, there are more collaborations with non-health partners such as Department of National Parks, Wildlife, and Plant Conservation, Department of Religious Affairs, Ministry of Labour, and Ministry of Social Development and Human Security (10th National Health Assembly, 2017). Such progress shows strong commitment from stakeholders to increase PA and reduce SB.

Rationale of the Study

Thailand has committed to improve PA and SB through multi-sectoral collaboration; however, the work is not complete. Given the complexity and differences in the Thai context where industrial and social transformations have taken place, the prevalence, trends and factors associated with PA and SB may not stay unchanged. Previous studies have also shown temporal changes in PA and SB internationally (Knuth & Hallal, 2009; Ng & Popkin, 2012). In addition, recent studies have also suggested that the amount of time spent in movement and non-movement behaviours (e.g., sleep, SB, quiet standing, LPA, MPA, and VPA) are dependent and should be considered as integrative parts of 24-hour day (Chastin et al., 2015; Dumuid et al., 2018; Pedišić, 2014). No studies in Thailand and only a few studies worldwide have so far determined levels and correlates of PA and/or SB acknowledging these methodological recommendations. Also, no previous studies in Thailand or in any other country analysed how correlates of PA and SB change over time. Therefore, to further facilitate the development of effective public health programs and policies to increase PA and reduce SB at the population level, there is a need for comprehensive epidemiological evidence and a sound research of prevalence, trends, and correlates of PA and SB in Thailand.

The key research questions of this PhD are:

1. What are the key gaps in the scientific literature concerning physical activity and sedentary behaviour in Thailand?
2. What is the prevalence of sedentary behaviour and insufficient physical activity in the Thai population?
3. What are the findings and limitations of previous studies concerning the correlates of physical activity and sedentary behaviour among the Thai population?
4. What are the time trends of physical activity and sedentary behaviour in the Thai population and how have the correlates of these behaviours changed over time?

Objectives of the Study

The aim of this project is to support the development of evidence-based strategies to promote PA and reduce SB in the Thai population. Sociodemographic correlates and trends of PA and

SB in Thailand were examined using time-use data, which allowed for treating PA and SB estimates as integrative parts of the time-use composition. This research pioneered its application when examining correlates and trends of PA and SB and it may, therefore, serve as an example for the future studies in this area. This PhD project is by publication, and it includes five papers. The titles and specific objectives of each publication are shown in Table 1.1.

Table 1. 1 The titles, specific objectives, and publication status

Paper 1	**Title:** Physical Activity and Sedentary Behaviour Research in Thailand: a Systematic Scoping Review **Objective:** Study 1 conducted a systematic scoping review of literature related to PA and SB in Thailand to identify research gaps and suggest possible directions for future studies. **Status:** Published in May 2018 in BMC Public Health (Q1; 5-year IF = 3.039, SNIP = 1.268)
Paper 2	**Title:** Do Thai People Meet Recommended Physical Activity Level?: the 2015 National Health and Welfare Survey **Objective:** Study 2 determined the prevalence of PA and SB among Thai adults using data collected in a large population-representative sample. **Status:** Published in June 2017 in the Journal of Health Systems Research (Thai Journal IF = 0.169)
Paper 3	**Title:** Correlates of Physical Activity and Sedentary Behaviour in the Thai Population: a Systematic Review **Objective:** Study 3 conducted a systematic review of individual, social, environmental, and policy-related correlates of PA and SB in the Thai population. **Status:** Published in April 2019 in BMC Public Health (Q1; 5-year IF = 3.039, SNIP = 1.268)
Paper 4	**Title:** Standardised criteria for classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity categories **Objective:**

	Study 4 developed criteria including MET estimates, wakefulness status, and posture to classify the ICATUS activities into sleep, SB, LPA, and MVPA categories, based on expert assessment. **Status:** Published in November 2019 on the International Journal of Behavioral Nutrition and Physical Activity (Q1; IF = 5.55; SNIP = 2.14)
Paper 5	**Title:** Trends and Correlates of Meeting 24-Hour Movement Guidelines: a 15-year Study among 167,577 Thai Adults **Objective:** Study 5 established 15-year trends of PA and SB and assess how correlates of these behaviours changed over time among Thai adults, using national time-use surveys. **Status:** Submitted to the International Journal of Behavioral Nutrition and Physical Activity and currently under review (Q1; IF = 5.55; SNIP = 2.14)

Contribution to Knowledge and Significance of the study

This doctoral research contributes to knowledge about Thai PA and SB in five ways. First, this research includes a scoping review providing the first comprehensive assessment of previous PA and SB studies conducted in Thailand. Such extensive scoping reviews are rarely conducted, because, depending on the number of studies, they may require a substantial amount of time and thus resources. However, the findings of such scoping reviews contribute strongly to the field as they enable identification of gaps in the literature. They also enable evidence-based recommendations to be made to guide future research directions. Second, levels, trends, and correlates of PA and SB are understudied in low- and middle-income countries (Bauman et al., 2012). In Thailand, trends in population levels of PA and SB have never been established. This PhD research provides evidence on levels, correlates, and trends of PA and SB in Thailand as well as essential information for policy makers and other public health stakeholders when developing public health interventions and strategies. Third, this project includes the first study to analyse how correlates of PA and SB change over time. This provides answers to several fundamental research questions, such as: 1) 'Can we consider findings of past and current studies of PA correlates to be conclusive, or should the studies be periodically repeated because of the possible changes of the findings in time?'; 2) 'Which correlates of PA are increasing in importance and which are decreasing?'; and 3) 'Is pooling of surveillance data from different years methodologically justified?'. This research also presents new methodology that can later be used in studies among other populations. Fourth, this research includes the first methodological study classifying the ICATUS activity groups into major health-related time-use components (i.e. sleep, SB, LPA, and MVPA) by linking the ICATUS activities with the standardised Compendium of Physical Activities (Ainsworth et al., 2011). This classification is of great importance to process the time-use data which is available worldwide (United Nations Statistics Division, 2018). Finally, this thesis includes one of the first studies on the correlates of meeting integrated 24-hour movement guidelines. This will also be the first study to employ time-use data in the context of PA and SB in low- and middle-income countries. This may become relevant globally, because time-use surveys have been conducted in more than 85 countries around the world (United Nations Statistics Division, 2018). Considering Thailand as an example of a middle-income country, findings of this research may be useful for shaping future research efforts in other countries of similar economic development.

Structure of the Thesis

This thesis is divided into nine chapters including; Introduction; Literature review; Methodology; A series of papers published in peer-reviewed journals or under editorial review; and Conclusions. Five papers included in the thesis were written as a stand-alone papers; therefore, some reiteration of the information presented in the Introduction chapter may be found in the manuscripts. The chapters are structured as follows;

Chapter I introduces the topics of PA and SB in relation to the leading global health agenda "NCDs". The magnitude of physical inactivity at the global level is described. The definitions, classifications, current situation, and significance of PA and SB on health outcomes are addressed. A brief background of the study context of "Thailand" and its policies on promoting active lifestyles are also highlighted. This chapter concludes with the main objectives and structure of the thesis.

Chapter II reviews the available evidence on prevalence, trends, and correlates of PA and SB in the international and Thai national contexts. Time use epidemiology and integrative concepts between movement and non-movement behaviours are also reviewed.

Chapter III describes the research methodologies and conceptual frameworks adapted in this project. It includes Scoping review, Systematic review, Coding techniques, Delphi survey, Social-ecological method, and the framework for Viable Integrative Research in Time-Use Epidemiology (VIRTUE).

Chapters IV - VIII present a collection of five original studies that have been published or submitted to peer-reviewed journals as parts of this PhD research.

Chapter IX concludes the study with a summary of findings received from all five studies included in the thesis. Discussions of the main findings, contributions and significance of the project are presented in the section including recommendations and future directions for future studies in the field.

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CHAPTER II: Literature Review

A plethora of evidence has shown strong associations of physical activity (PA) and sedentary behaviour (SB) with health outcomes; hence, monitoring PA and SB levels is important for public health. This chapter is structured to review core aspects of PA and SB under the behavioural epidemiology framework and its construct; measurement and methods; and factors influencing the behaviours. An extensive review of literature also addresses time-use epidemiology, relating more specifically to measurement in PA research. This chapter, therefore, investigates the following topics: i) Worldwide Trends of Physical Activity; ii) Prevalence and Trends of Physical Activity in Thailand; iii) Worldwide Trends of Sedentary Behaviour; iv) Assessment and Measurement of Physical Activity and Sedentary Behaviour; and v) Time Use and Movement Perspectives.

Worldwide Trends of Physical Activity

PA and physical inactivity are multi-dimensional behaviours which they occur in a different context. PA has a well-established role in health promotion and disease prevention, while physical inactivity and SB are a major risk factor for many common 'lifestyle' diseases such as cardiovascular disease, type II diabetes, and metabolic diseases (Malina, Cumming, & Coelho-e-Silva, 2016). Surveillance and monitoring systems to measure PA and SB are fundamental to advancements in public health (Kohl et al., 2012). Many countries have measured the prevalence of PA and SB; however, consistent prevalence data to provide trend information in these behaviours are still scarce (Guthold, Stevens, Riley, & Bull, 2018; Hallal et al., 2012; Sallis et al., 2016). Availability of comparable estimates for insufficient PA among countries in the WHO Global Health Observatory (GHO) is a significant introduction to global trend studies in PA research. The GHO is the 'one-stop shop' initiative implemented by the WHO to serve as the world's largest database (World Health Organization, 2012). It is a free and accessible platform for comprehensive health data and statistics that are available within WHO (World Health Organization, 2012). The GHO data include a wide range of global health issues such as NCDs, mortality and burden of disease, and health systems.

A series physical activity papers in the Lancet and Lancet Global Health used prevalence estimates of insufficient PA from the WHO GHO to compile between-country data and produce global estimates of physical inactivity from 2001 to 2016 (Guthold et al., 2018; Hallal et al., 2012; Sallis et al., 2016). First, the global prevalence of inactivity was estimated among adult populations in 122 countries in the 2012 Lancet Physical Activity series. Later in 2016, Sallis and colleagues updated the estimates and included more adult participants from 146 countries. Between two-point estimates, the worldwide insufficient PA shows a declining change from 31.1% to 23.3% (Hallal et al., 2012; Sallis et al., 2016). However, Sallis et al.

(2016) noted that this decline was mainly explained by the different definition of insufficient PA used in the two studies, not a real decreasing trend (Sallis et al., 2016). In 2012 paper, physical inactivity was defined as not having 30 minutes of MPA for at least 5 days per week, or 20 minutes of VPA for 3 days per week, or an equivalent combination (Hallal et al., 2012). With the updated PA recommendations, in 2016 paper, physical inactivity was defined as not having 150 minutes of MPA or 75 minutes of VPA per week, or an equivalent combination (Sallis et al., 2016). The updated recommendations do not concern about the weekly frequency and can be achieved more easily (Sallis et al., 2016). The stable trend of physical inactivity in adult populations is confirmed by the latest Lancet Physical Activity paper (Guthold et al., 2018). With a pooled analysis of nearly 2 million adult participants from 168 countries, the global trend of insufficient PA only slightly changed from 28.5% in 2001 to 27.5% in 2016 (Guthold et al., 2018).

Previous studies also observed the trends on PA and physical inactivity based on pooled data from several individual studies. For example, Knuth and Hallal (2009) systematically reviewed temporal trends of PA from 41 studies only from high-income countries. As studies from low- and middle-income countries were not found, possibly because there was less PA surveillance research (Knuth & Hallal, 2009) and/or no publications in English available. Knuth and colleagues found that among adults, leisure-time PA increased over time, whereas occupational PA showed the opposite trend. Trend studies for children and adolescents were less developed. Only nine studies were identified in this systematic review. Of these, six studies showed decreasing overall PA trends, while the increasing trends found in one study. Stabilisation in PA levels was found in the remaining two studies. Interpreting results from a compilation of different studies is challenging according to methodological inconsistencies (e.g., data collection, outcome variables, inclusion criteria, and difference of surveillance points) used in each study (Kalman et al., 2015; Sallis et al., 2016).

Another example examined trends of MVPA among adolescents (aged 11 – 15 years old) across 32 countries from Europe and North America between 2002 and 2010 (Kalman et al., 2015). This study included only articles that used the same school-based survey, the Health Behaviour in School-aged Children (HBSC). Overall, the majority of adolescents did not meet the PA recommendation (i.e., at least 60 minutes of MVPA daily); however, the proportion of young people who met the guidelines slightly increased from 17% in 2002 to 18.6% in 2010. Findings from this study also show a variation in MVPA trends at a country level. There were significantly positive trends in 16 countries and stable levels in seven countries. While nine countries showed a significant decrease. This study, nevertheless, produced reasonably robust analysis of trends as research methods of these studies are comparable. The consistency of methodologies used in research is a critical element in trend analyses, as incomparability may occur when comparing prevalence estimates from different surveillance systems (Carlson, Densmore, Fulton, Yore, & Kohl, 2009). For example, Carlson and colleagues (2009) observed PA trends in the U.S. population using three leading U.S. surveillance systems; namely, National Health Interview Survey (NHIS) from 1998 to 2007, National Health and Nutrition Examination Survey (NHANES) from 1999 to 2006, and Behavioral Risk Factor Surveillance System (BRFSS) from 2001 to 2007. These three systems provided different results. The proportion of being sufficiently active increased and inactivity decreased significantly from prevalence estimates in the BRFSS, whilst no significant trends found in the NHIS. Physical inactivity also decreased significantly in the NHANES, but no significant trends shown for PA. It is recommended that the methodology of included studies be comparable in all aspects to ensure rational comparisons (Carlson et al., 2009).

Global trends provide an overview of the situation and are crucial to track progress across countries especially when there is a common aim to reach, for example, the NCD target of 10% relative reduction of physical inactivity by 2025 (World Health Organization, 2014). However, prevalence of insufficient PA can vary across countries, regions, and income groups (Guthold et al., 2018; Kalman et al., 2015). Monitoring trends at a country level is, therefore, needed for the development of national strategies to promote PA participation. Most countries have now conducted a population-based survey of PA mostly to align with the WHO Global Action Plan on NCDs and to achieve the WHO recommendations on PA (Sallis et al., 2016). Even though surveillance and monitoring systems have been put in place in several countries, there is a general lack of data on PA trends in most countries (Craig, Russell, Cameron, & Bauman, 2004). Currently, trend data are available mostly from high-income countries (Guthold et al., 2018). For example, PA trends for the U.S. adult population are available from 1986 to 2017 (Carlson et al., 2009; Caspersen & Merritt, 1995; Whitfield et al., 2019). Over this period, the prevalence of American adults who met recommended levels of PA increased but remained low from around 22% in 1986 to 24.3% in 2017. Consistent with the American trend, Canadian adults had an upward trend of meeting PA guidelines between 1981 and 2007 (Bryan & Katzmarzyk, 2009; Craig et al., 2004).

Leisure-time PA also increased in the Finnish population during the 40-year period of 1972 to 2012, but the prevalence of occupational and travel PA decreased (Borodulin et al., 2016; Borodulin, Laatikainen, Juolevi, & Jousilahti, 2007). Similar findings were found in English men and women, where an increasing trend showed for overall PA participation and adults meeting the PA guidelines, but a declining level in occupation PA was found between 1999 and 2004 (Stamatakis, Ekelund, & Wareham, 2007). In contrary to those in the abovementioned countries, the sufficient PA levels declined among Australian adults during 1997, 1999 and 2000 (50.9%, 45.2%, and 46.1%, respectively), while the level of inactivity rose from 13.4% in

1997 and 14.6% in 1999 to 15.3% in 2000 (A. Bauman et al., 2003; A. Bauman, Ford, & Armstrong, 2001). However, more recent trend data at a state level showed an increasing trend in Australian adults. The PA data collected for the state of New South Wales in 1998, and 2002 to 2005 reported an increase of adults achieving sufficient PA in the last two survey years (47.6% in 1998, 46.5% in 2002, 44.7% in 2003, 50.5% in 2004, and 51.3% in 2005) (J. Chau et al., 2008). Similar trends were observed in the Queensland state where an average of 3% increase per year reported from 2002 to 2008 (Vandelanotte, Duncan, Caperchione, Hanley, & Mummery, 2010).

Fewer studies have observed trends on PA and physical inactivity in young and older populations (J. Adams, 2006; Keadle, McKinnon, Graubard, & Troiano, 2016). In Canadian children and youth, temporal trends in energy expenditure of leisure-time PA were studied from five nationally cross-sectional surveys conducted in 1981, 1988, 1994, 1996, and 1998 (Eisenmann, Katzmarzyk, & Tremblay, 2004). The level of energy expenditure in the leisure domain increased between the 1981 and 1988, and remained stable since. The reported stability of PA was also found afterwards from two later studies. First, Irving et al. (2003) examined trends in VPA among adolescents from Ontario, Canada. They found steady patterns of VPA throughout the 1997, 1999 and 2001 survey years. The second study also suggests no change of MVPA in Canadian children and youth over the 9-year period from 2007 to 2015 using accelerometer-based data (Colley et al., 2017). Change in PA levels was also objectively measured in Swedish children using a pedometer (Raustorp & Ludvigsson, 2007). The findings indicate that there was a significant increase in step counts per day between two-point estimates of 2000 and 2006 among Swedish children.

Among studies focusing on children and adolescents, several studies have focused on changes in VPA. The analysis of data from the United States Youth Risk Behaviour Surveys (YRBS) between 1991 and 2003 shows small decreased engagement in VPA and increased physical inactivity among adolescents (J. Adams, 2006). In European countries between 1986 and 2002, some evidence of small increase in regular VPA was found in Finland, Scotland, and Wales (Samdal et al., 2006). While adolescents in Austria, Hungary, Norway, and Sweden remained their VPA levels across the 16-year period (Samdal et al., 2006). Similar unfavourable shifts in PA patterns are also found in longitudinal studies. Five-year cohort studies between 1999 and 2004 show longitudinal decreases in MVPA in U.S. adolescents and in VPA in British youths (Brodersen, Steptoe, Boniface, & Wardle, 2007; Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006).

Even though there is a strong negative association between age and PA levels, there is little published data reporting temporal changes in older populations (Keadle et al., 2016). Similar to the study of Carlson et al. (2009), trends of U.S. older adults who met PA guidelines (i.e., 150 min/week of MVPA) were determined using the three U.S. surveillance systems (i.e., BRFSS between 1999 and 2012, NHANES between 1998 and 2013, and NHIS between 1994 and 2014). The proportion of older adults meeting the guidelines increased over time in all three surveys, and significant reductions in no leisure time PA were also reported except for the NHANES (Keadle et al., 2016). Prior to this study, physical inactivity among U.S. older adults was examined specifically by states during 1987 to 1992, using data from the BRFSS (Centers for Disease Control Prevention, 1995). Among older adults from 33 studied states, they found a moderate decline in physical inactivity over time. However, physical inactivity was defined as reporting no leisure time PA in this study (Centers for Disease Control Prevention, 1995).

Trend data of PA and physical inactivity is less developed in low- and middle-income countries, including Thailand, compared to high-income nations (Guthold et al., 2018). The lack of trend information is also shown as no representative national surveillance system implemented in many countries of low- and middle-income status (Global Obervatory for Physical Activity, 2019). The Global Observatory for Physical Activity (GoPA) compiled and summarised standardised country-level data on surveillance, policy and research as ‘country cards’ (Global Obervatory for Physical Activity, 2019). The GoPA obtained PA data from 217 countries, and of these, 139 countries have a ‘country card’ with completed information (Global Obervatory for Physical Activity, 2019; Varela et al., 2017). Of the 139 participating countries, 33.3% of low-income countries had no completed national survey on PA compared with 7.6% of high-income countries (Varela et al., 2017). In addition, research publications on PA are less available in low- and middle-income countries. According to PA-related research in each country obtained in GoPA, more than 83% of articles related to PA and public health were published in high-income countries (Varela et al., 2017). Almost 50% of PA publications available on PubMed in 2013 come from six high-income countries; namely, Australia, Canada, Netherlands, Spain, the United Kingdom, and the United States (Global Obervatory for Physical Activity, 2019). Brazil and China are the only two countries from low- and middle-income status that produce articles on PA in the top 20 (Global Obervatory for Physical Activity, 2019).

Based on the country card for Thailand, there are only four PA-related publications found from PubMed search in 2013 (Global Obervatory for Physical Activity, 2019). Even though, there were no language restrictions in search procedures (Varela et al., 2017), peer-reviewed articles of PA in Thailand indexed in PubMed may be restricted to English studies only. Therefore, to provide a comprehensive epidemiological evidence on PA in Thailand, there needs a thorough assessment with studies written in the Thai national language included. Moreover, searches should be conducted through more databases.

Prevalence and Trends of Physical Activity in Thailand

Improvements in global surveillance systems of PA have made comparability possible, and thus trend data should be available from more countries in the future. Prevalence of PA and physical inactivity in Thailand is also available on these standardised surveillance platforms. On the country card Thailand, prevalence of physical inactivity among adults was 30% in 2014 (Global Obervatory for Physical Activity, 2019). While prevalence of physical inactivity among Thai adults was 24.6% in 2016, and 84.4% among adolescents in 2010, based on the WHO GHO (World Health Organization, 2015, 2018). In Thailand, the level of sufficient PA participation has been monitored at the national level initially in 2003 when PA questions were included in the 3rd National Health Examination Survey Thailand 2003-2004 (Health System Research Institute, 2006). The sufficient level of PA is based on the WHO recommendations on PA for adults or meeting a minimum of 150 minutes of MPA or 75 minutes of VPA or an equivalent combination of both intensities per week (World Health Organization, 2010). Most Thai national surveys included participants aged 15 years and over and used the global standardised questionnaires; namely, International Physical Activity Questionnaire (IPAQ) and Global Physical Activity Questionnaire (GPAQ) (Division of Physical Activity & Health, 2015).

The population prevalence of sufficient PA varied among national surveys (Division of Physical Activity & Health, 2015). In 2007, the Institute for Research and Academic Services, Assumption University conducted a national survey in the Thai population aged 15 years old and over (Institute for Research and Academic Services, 2008). They used GPAQ to observe the PA level and found 85.4% of Thai people had enough PA. While another national survey conducted in the same year by the Department of Disease Control found 92.5% in the population were physically active using the same questionnaire (Division of Physical Activity & Health, 2015). In 2015, four organisations; namely, the Population and Social Research Institute, Mahidol University; Health System Research Institute, Ministry of Public Health; the National Statistical Office, Ministry of Information and Communication Technology; and the Department of Disease Control, Ministry of Public Health, conducted a survey to observe the PA participation in the population. The level of PA sufficiency varied between below 45% to more than 80% (Division of Physical Activity & Health, 2015; Ketwongsa, 2015). A wide range of PA levels may be explained by inconsistencies in the methodology used in each survey by different organisations. For example, the survey conducted by the Population and Social Research Institute employed GPAQ in addition to 24-hour diary to examine PA levels in Thai people aged at least 5 years old (Ketwongsa, 2015). The number of sample size was much smaller in this survey than the other surveys (Division of Physical Activity & Health, 2015).

Physical inactivity is a cause of 5.1% of all deaths in Thailand (Global Obervatory for Physical Activity, 2019). Consequently, PA and physical inactivity have been monitored at a national level. Although, a surveillance system has been implemented and national surveys have been conducted in Thailand, published data on trends of the behaviours in the population is not available. Trend information provide tracked changes in PA prevalence which is essential to identify needs in intervention development and assess the effectiveness of population-based public health programs (Dishman, Heath, & Lee, 2012). To produce time trends of PA estimates, all aspects of the methodology used over different data points need to be examined to determine comparability (Carlson et al., 2009). However, PA prevalence from Thai national surveys has been estimated from a variety of sources. No published study has, therefore, directly compared data to report temporal trends of PA and/or physical inactivity in the Thai population.

Worldwide Trends of Sedentary Behaviour

High SB may lead to adverse health outcomes, and it might be that this is exacerbated among those whose PA is low (Biddle et al., 2019; de Rezende, Lopes, Rey-Lopez, Matsudo, & do Carmo Luiz, 2014; Ekelund et al., 2016; Katzmarzyk et al., 2019; Owen, Healy, Matthews, & Dunstan, 2010). Sitting time is found to be responsible for 3.8% of all-cause mortality across 54 countries worldwide (Rezende et al., 2016). The increase of all-cause and cardiovascular disease mortality is significantly associated with high level of TV viewing time independently of other risk factors such as smoking, blood pressure, cholesterol and diet, leisure time PA, and waist circumference (Owen et al., 2010).

With adverse health consequences of sedentary time, surveillance research on SB has shown rapid growth. Over the past 50 years, time spent in sedentary activities appear to have increased especially through TV viewing (Clark & Sugiyama, 2015). SB is prevalent in many countries particularly in high-income economies. Bauman and colleagues examined the prevalence of high sitting time in adults from 20 countries across economic development levels (Bauman et al., 2011). More than one fourth of adult populations (25.2% - 34.9%) reported high sitting time of 9 – 17 hours/day specifically in high-income countries (i.e., Lithuania, Hong Kong, Saudi Arabia, Norway, Taiwan, and Japan). The global trends show a shift from physically active to sedentary lifestyles around the world regardless of their status of economic development (Katzmarzyk & Mason, 2009; Ng & Popkin, 2012). However, overall trends in SB are not yet conclusive (Clark & Sugiyama, 2015). Population-based studies to explore changes in SB are rarely investigated over time, except for few studies conducted mostly in high-income countries.

Among the U.S. population, sedentary time significantly declined among children, but no significant change was observed in adolescents and adults from 2001 through 2016 (Yang et al., 2019). Conversely, older adults in America significantly spent greater amount of sedentary time over the same 16-year period (Yang et al., 2019). In Australia, overall non-occupational SB slightly increased in the Australian adults from 1997 to 2006 (Chau et al., 2012). The increase appears to be the result of sedentary time in transportation and education domains, while household and leisure time SB were kept stable (Chau et al., 2012). Later from 2007 to 2013, overall total sitting time remained fairly constant in middle-aged Australian adults, at average nearly 10 hours per day (Mielke, Burton, Turrell, & Brown, 2018). However, when observed by domain-specific sitting time, there were significant increases in home computer use and TV viewing. On the other hand, Dutch adults had a decreased non-occupational sedentary time by 4.5 hours per week over the 30-year period (1975 – 2005) (van der Ploeg et al., 2013). The decrease was mainly due to a decline in SB during leisure time, from 90% in 1975 to 84% in 2005. While in a transportation domain, time spent in inactive modes of transport increased by 2 hours per week over this period. Another study investigated time trends in adult sitting time across 27 European countries (Milton, Gale, Stamatakis, & Bauman, 2015). The results show a constant level of total sitting time between 2002 and 2013; however, the high sitting time of more than 7 hours per day decreased (Milton et al., 2015). For adolescent populations, another study examined TV viewing time among adolescents from seven European countries and found no clear patterns during 1986 and 2002 (Samdal et al., 2006).

Prevalence and Trends of Sedentary Behaviour in Thailand

SB epidemiology is a young research area and it is largely understudied in low- and middle-income South East Asian countries, including Thailand (Peltzer & Pengpid, 2016). Very few national studies have monitored the prevalence of SB in the Thai population. The Institute for Population and Social Research, Mahidol University conducted a national survey using GPAQ to assess sedentary time among Thai people aged 5 years and older (Institute for Population and Social Research, 2016). They found that Thai people spent approximately 13 hours in SB in 2012 and 2013 (Institute for Population and Social Research, 2016). The top two sedentary activities that Thai people engaged in were TV watching (86.7%) and sitting at work (51.9%) (Institute for Population and Social Research, 2016). The prevalence of SB among Thai adults seem to have increased since a large-scale study of 74,981 adult students aged 20 – 50 years that was conducted in 2005 – 2006 (Banks, Lim, Seubsman, Bain, & Sleigh, 2011). This study found that average sitting time was 6.6 hours/day, and that 46.6% of women and 36.8% of men spent 8 or more hours a day in SB (Banks et al., 2011).

In the fourth National Health Examination Survey (NHES IV) conducted in 2008 – 2009, there were also questions on the time spent watching TV and computer gaming among Thai children (Mo-suwan, Nontarak, Aekplakorn, & Satheannoppakao, 2014). In this national survey, Mo-suwan and colleagues found 89.3% of Thai children aged 6 – 14 years old watched TV for more than 2 hours/day and 5.2% of them played computer games for more than 1 hour/day (Mo-suwan et al., 2014). The prevalence of SB among Thai youth was also established in multinational studies. Thailand took part in a cross-sectional school survey conducted between 2007 and 2013 to assess leisure time SB from seven ASEAN countries using the Global School-based Student Health Survey (Peltzer & Pengpid, 2016). The survey data shows that 39.6% of Thai school-aged adolescents (13–15 years) spent 3 or more hours sitting when not in school or doing homework, which is higher than the overall prevalence in all participating countries (33.0%) (Peltzer & Pengpid, 2016).

A high prevalence of SB was also found among Thai university students in an IPAQ-based study in 18 low- and middle-income countries conducted in 2013 (Peltzer & Pengpid, 2014). The prevalence of Thai students who reported more than 4 hours of sitting was 36.2%, which was considered to be high when compared to the average prevalence of all students from 18 participating countries (22.0%) (Peltzer & Pengpid, 2014). The prevalence of high SB among Thai children and adolescents has continued to grow, as shown in more recent Thailand's report card results. More than 78% and 74% of Thai young people had leisure screen time of more than 2 hours/day in 2016 and 2018 respectively (Active Healthy Kids Global Alliance, 2018; Amornsriwatanakul et al., 2016).

However, with a limited number of trend studies in the representative sample of Thai adult population, monitoring changes in SB over time in the Thai population is still needed. Given the magnitude of inactivity crisis in most countries around the world, it is necessary to concurrently monitor trends of both PA and SB over time. Future trend studies are needed to improve surveillance evidence in the country and help achieve the 2025 global PA target (i.e., a 10% physical inactivity reduction; World Health Organization, 2013). In addition, because the behaviours may vary across different social, cultural, and environmental characteristics, the country-specific exploration of trends is needed.

Assessment and Measurement of Physical Activity and Sedentary Behaviour

There is a clear need to monitor and track progress of PA and SB in a population. Surveillance and monitoring systems are important measurements and should be available to produce data that can be used in public health practices to improve PA and SB levels. In addition, valid and reliable methods to observe prevalence and trends should also be taken into great consideration. There are several methods to estimate these behaviours such as questionnaires, diaries, movement counters, and objective observations (Malina et al., 2016). The advancement of technologies to estimate energy expended through PA is relatively progressive with recent development of the doubly labelled water (DLW), which is claimed as the 'gold standard' to measure total energy expenditure in all age groups of populations (Malina et al., 2016). However, it is generally accepted that there is no single tool that can precisely assess all aspects of PA and SB epidemiology (Malina et al., 2016).

Numerous observational studies have estimated the population prevalence of PA and SB using self-reported PA questionnaires, such as IPAQ and GPAQ (Guthold et al., 2018; Hallal et al., 2012; Sallis et al., 2016). Questionnaire-based measures have limitations involved with recall errors and subjectivity which may result in the underestimation or overestimation of the observed associations (Matthews et al., 2018). Validation studies utilising device-based measures of PA suggest that validity of traditional PA questionnaires may be limited (Ara et al., 2015). A 2018 measurement study also concluded that validity of PA estimates was better for an internet-based 24-hour recall and accelerometer than for traditional surveys when compared to the 'gold standard' DLW (Matthews et al., 2018). Given known limitations of self-report measures of PA, the application of device-based measures (e.g., accelerometers and pedometers) to conduct large-scale prevalence observations is increasing (Sallis et al., 2016). Device-based measures of PA have now become feasible in nationally representative epidemiological studies (I.-M. Lee & Shiroma, 2014). Although these device-based measures have better reliability and validity than questionnaire-based measures of PA and SB, issues with generalisability, simplicity, affordability, and comprehensiveness limit their utility for large-scale studies (Pedišić & Bauman, 2015).

Although devise-based methods should be a better choice for PA assessment, due to relatively high costs of device-based techniques, they are rarely used in low- and middle-income countries. In addition, survey methods remain valid with advantages such as simplicity and cost-efficacy (Ara et al., 2015). Self-report questionnaires are, therefore, generally used in large epidemiological studies and health surveillance systems, despite their limitations (Malina et al., 2016; Shephard & Aoyagi, 2012). A combination of both subjective methods (to capture domain-specific information) and device-based measures (to obtain more accurate accumulation of PA and SB time) has been recommended for future assessment studies (Ara et al., 2015; Healy et al., 2011). In Thailand, self-report questionnaires have been used in population-representative surveys conducted to assess PA and SB (Division of Physical Activity & Health, 2015). Very few studies employed accelerometers and pedometers to assess the behaviours, and these studies were all conducted in small-scale samples (Konharn, Santos, & Ribeiro, 2014, 2015; Sitthipornvorakul, Janwantanakul, & Van Der Beek, 2014). There are also only few academic publications about PA and SB levels in the Thai population using large-scale population-representative samples.

Potential Correlates of Physical Activity and Sedentary Behaviour

To design effective interventions to increase PA participation in populations and select the priority target groups, it is important to understand and be able to identify factors that are associated with higher and lower levels of PA. Correlational studies have received a lot of attention worldwide to serve this purpose. There are several published papers examining relationships between PA and SB with a number of factors. To explain or predict outcome behaviours from these associational studies, it is essential to understand the logical relationships that can be relatively generated from the studies. As clarified in the study by Bauman, Sallis, Dzewaltowski, and Owen (2002), based on the research design, the relationship produced from a longitudinal observational and experimental study is more likely to be causal; therefore, supports causal inferences. Associations obtained from these studies are ‘determinant’. While research with a cross-sectional design provide only statistical relationships which can generally make hypotheses for further study, and thus refer to as ‘correlate’ (Bauman et al., 2002).

PA and SB are like other health behaviours that can be influenced by multiple levels of factors (Giles-Corti & Donovan, 2002). Investigating single-level factors in isolation may not provide a comprehensive solution to improve the behaviours. The socio-ecological model has been widely adopted to understand the interrelationships between different categories of variables associated with PA and SB including individual, social, physical environment, and policy-related attributes (Sallis, Owen, & Fisher, 2008). With a plethora of correlate studies, systematic reviews of PA correlates at a global scale are available. Previous reviews addressed and examined the full spectrum of correlates and determinants of PA (Sallis et al., 2016; Sallis, Prochaska, & Taylor, 2000; Trinh et al., 2016; Trost, Owen, Bauman, Sallis, & Brown, 2002). Bauman and colleagues summarised available reviews of possible PA influence among children, adolescents, and adults, and categorised them into five groups based on the socio-ecological model including i) demographic or biological; ii) psychosocial; iii) behavioural; iv) social and cultural; and v) environmental variables (Bauman et al., 2012).

Most included studies used cross-sectional designs and focused at an individual level of correlates. These factors varied across age and geographical groups. There were few consistent correlates of higher PA; namely, male sex, self-efficacy and previous PA behaviour that were consistent across all age groups; health and intention to exercise only in adults; and family support in adolescents. Even though there were no language restrictions in search strategies, most previous systematic reviews included studies that were written in English and conducted in high-income countries. More associational studies are still needed, especially from low- and middle-income countries.

Correlational literature on SB also exists, but it is much less developed than for PA. SB correlates in the adult population were summarised in previous reviews using a socio-ecological approach (O'donoghue et al., 2016; Prince, Reed, McFetridge, Tremblay, & Reid, 2017; Rhodes, Mark, & Temmel, 2012). Findings are broadly similar to those for PA, as individual level factors were mostly examined in cross-sectional samples and reliably linked with SB. For instance, adults with older age, female sex, higher body mass index (BMI), living in urban, and no reported PA participation tended to have higher SB level. The results also show that investigations on interpersonal, social and environmental factors, that may also be significant contributors to a higher SB level in this population, increased. However, there still needs further research, particularly in these types of correlates to understand SB at a full coverage of socio-ecological framework. In addition, it should be noted that articles included in these reviews were restricted to English-language only; therefore, the vast majority of studies were those conducted in high-income countries such as North America, Australia, England, Canada, European countries, and New Zealand.

There are also systematic reviews conducted to determine multilevel factors associated with SB among children, adolescents, and older adults (Chastin et al., 2015; Uijtdewilligen et al., 2011; Van, Paw, Twisk, & Van, 2007). Most published data used cross-sectional samples, except the review by Uijtdewilligen et al. (2011) which analysed only studies with a prospective design. However, with very limited number of studies included in these reviews, current evidence is insufficient, and consequently difficult to draw conclusions. Individual level factors of SB were most frequently investigated in these populations. Based on available results, sex, BMI, depression, ethnicity, socioeconomic status, and education levels of parents were strong correlates of TV viewing in children and adolescents (Van et al., 2007). For determinants of SB, there was only one determinant found for a positive association between BMI and SB in children (Uijtdewilligen et al., 2011). For older adults, consistent correlates of SB were positively found for age, and negatively for retirement, obesity and health status (Chastin et al., 2015). However, these summaries are mainly based on data from high-income countries.

As several previous studies emphasise on the dearth of correlation summary in low- and middle-income countries, recent reviews focused on these understudied populations and summarised potential associations of PA and SB in all age groups (Bauman et al., 2012; Koyanagi, Stubbs, & Vancampfort, 2018; Sallis et al., 2016). From these reviews, it is evident that correlational research has increased in low- and middle-income countries. According to Sallis et al. (2016), the number of publications on PA correlates conducted in low- and middle-income countries increased considerably between 2012 and 2015 (32.8 papers per year), compared to a previous decade (1999 – 2011) (7.2 studies annually). However, they noted that this increase was mostly from a few upper-middle income countries such as Brazil and China. This finding is consistent with the summary in Bauman et al. (2012) where they identified two-thirds of the studies in low- and middle-income countries were also from these two nations. A more recent review also identified correlates of physical inactivity among adults and older adults who spent less than 150 minutes of MVPA per week in 46 low- and middle-income countries (Koyanagi et al., 2018). Overall, some findings show consistencies of demographic correlates among adults and older adults across all reviews. These consistent correlates of higher PA include male sex, younger age, lower socioeconomic status, living in rural, and employment status. These findings also highlight the importance of reductions in SB as one of the public health priorities according to rapidly increasing economic growth and urbanisation in low- and middle-income economies.

There are also some inconsistencies existing across countries regardless of income status. For example, PA levels increase when age decrease in low- and middle-income countries. However, an inverse association is found among older adults in China (Bauman et al., 2012). This, therefore, indicates possibly different associations at a country level and calls for country-specific studies on correlation.

Correlates of Physical Activity and Sedentary Behaviour in Thailand

Existing literature provides a comprehensive overview of associations of PA and SB with numerous factors, ranging from intrapersonal to policy-related attributes. Being able to identify significance and consistencies of these factors that can encourage and/or discourage favourable behaviours is linked to improvements of public health interventions. Moreover, as differences exist between countries, associations of health behaviours may also be country-specific and need investigations at a country level. To date, there are several individual studies that investigated correlates of PA and SB in Thailand. Most studies examined demographic and psychological variables of the behaviours. Two large national studies indicate that the risk of being obese was strongly related to screen time (i.e., TV viewing or using computers), but inversely associated with greater amount of time spent in housework or gardening in Thai adults (Banks, Lim, Seubsman, Bain, & Sleigh, 2011; Banwell et al., 2009). Findings from Thailand show some inconsistencies of associations between gender and PA levels with many previous studies. Female sex, higher education, and married status tend to engage more in exercise-related PA than their counterparts in the Thai population (Siramaneerat & Sawangdee, 2015). While male and wealthy elderly were less likely to participate in PA (Ethisan, Somrongthong, Ahmed, Kumar, & Chapman, 2016). Perceived self-efficacy and intention to exercise were also found to have influence on exercise behaviour in Thai adults (Poomsrikaew, Berger, Kim, & Zerwic, 2012), similarly to other countries (Bauman et al., 2012). Some small-scale studies used device-based instruments to monitor the behaviours. For example, Konharn and colleagues used accelerometers to measure PA and SB levels among Thai youths and found that adolescents from low socioeconomic status spent more time in PA and less time in SB than those of high socioeconomic status (Konharn et al., 2014).

Factors in social and physical environments have also been investigated in the Thai context, but much less than intrapersonal level. For instance, social support and neighbourhood environment and facilities had non-significant relationship with PA levels in Thai older adults (Kraithaworn, Sirapo-ngam, Piaseu, Nityasuddhi, & Gretebeck, 2011). While friendships and friendship-making ability were positively associated with overall PA participation in Thai adolescents (Page, Taylor, Suwanteerangkul, & Novilla, 2005). Correlational research is increasing across countries, specifically in high- and middle-income countries, including Thailand. Numerous PA and SB associations have been explored beyond individual level; however, a comprehensive review summarising correlation evidence at all levels is virtually non-existent in the Thai context. Moreover, correlate information of PA and SB in Thailand were not summarised in previous literature reviews. Therefore, in Thailand there lacks of detailed review summarising available literature related to multiple levels of factors that influence the participation of PA and SB. With increasing evidence on correlates of PA and SB, it is also possible and important to observe if there is any change of common correlates over time. It would be most beneficial to determine changes in associations which are rarely identified.

Time-use and 24-hour Movement Perspectives

Time-use data have recently been found among population measurements to bring a comprehensive context of all activities during the 24-hour day to PA research (Bauman, Bittman, & Gershuny, 2019). Time-use methodology can provide real data of people’s lifestyles allowing accurate judgements, which is important to empirical research (Harvey & Pentland, 1999). Time-use studies are designed to collect detailed data on time spent in daily activities in which individuals engage (United Nations Statistics Division, 2018). This information can be gathered with other information such as location where the activity takes place, any person who is co-present during the activity, any income earned from performing the activity, and stress or satisfaction perceived from the activity. With a broad range of contextual information, data obtained from time-use studies are comprehensive and include invaluable information to understand different population problems across disciplines (e.g., sociology, economics, and public health) (Deyaert, Harms, Weenas, Gershuny, & Glorieux, 2017; van der Ploeg et al., 2010).

History of Time-Use Research

The study of time use has its origin in sociology and was first used in 1913 to examine the relationship between hours of labour and the use of spare time in 806 working men in the United States (Bevans, 1913). During the following few decades, a large body of time-use research was undertaken which focused on i) broad categories of activities in the daily, weekly or yearly time budget of the population such as employment, household tasks, personal care, recreation and sleep; ii) characteristic time expenditures of specific social groups (e.g., unemployed men, college students); and iii) free time or leisure (Szalai, 1972). Time-use data and surveys have been conducted in a nationally representative population since the 1960s, mainly in the fields of sociology and economics (Deyaert et al., 2017). The United States started to measure market work hours using the Current Population Survey (CPS) in 1962 (Aguiar, Hurst, & Karabarbounis, 2012), and later in 1965 Canada undertook a time-use survey in industrial workers (Harvey & Pentland, 1999). One of the classic time-use studies was the cross-national survey conducted in the mid-1960s by Alexander Szalai using the Multinational Time Use Study (MTUS) to collect and compare time diary data of 30,000 people from 12 countries, seven of them in Eastern Europe, three in Western Europe, the United States and Peru (Szalai, 1972).

Many economic phenomena have been explained over the studies of the allocation of time. For instance, the incorporation of time in non-market work or home production into the standard labour supply model provides a deeper understanding of the measurement of the elasticity of labour supply (Aguiar et al., 2012). The utilisation of time-use data was also explored in relation to public health concerns. Bird and Fremont (1991) used data from the 1981 Study of Time Use to analyse gender differences and overall health. They found that spending more hours in paid work improves health, while housework does the opposite. They concluded that men’s health was better than women’s because of higher education, higher wages, and more time spent at paid work. More than 85 countries worldwide have now measured how their populations allocate their time across life domains (United Nations Statistics Division, 2018). Many countries conduct recurring time-use surveys every four to ten years, for example, Canada, Norway, Australia, the Netherlands, Japan, and Thailand (Harvey & Pentland, 1999; United Nations Statistics Division, 2018).

Time-use studies include a variety of methodologies such as direct observation, activity frequency and duration surveys, and time diaries (Harvey & Pentland, 1999). Direct observation is accurate but costly, while activity frequency and direction surveys generally include a long list of activities to be completed by respondents; therefore, leading to increased respondent burden and lower response rates (Harvey & Pentland, 1999). Most time-use studies employ a self-reported diary of the sequence and duration of activities engaged in during a specified period, most typically a 24-hour day (United Nations Statistics Division, 2018). Time-use diaries provide more valid and acceptable data quality compared to other time-use measures (Juster, 1985; Robinson, 1985). Furthermore, since respondents record all activities in time-use diaries using their own words, this may be easier for respondents and reduce their time to complete a diary. The recorded activities are later coded according to classification criteria. There are several national and international time-use classifications available, such as International Classification of Activities for Time Use Statistics (ICATUS), American Time Use Study (ATUS), Australian Time Use Activity Classification, and Harmonised European Time Use Survey (HETUS).

Time-use and Physical Activity Research

Given the comprehensive data obtained from time-use surveys, there are advantages of utilising time-use data for PA surveillance over traditional self-reported questionnaires (van der Ploeg et al., 2010). Firstly, since participants are asked to record all activities undertaken throughout the day, not specifically PA-related information, these spontaneous and continuous records across 24-hour period may reduce reporting bias towards social desirability, which favours high PA and possibly affects PA-focused surveys (van der Ploeg et al., 2010). Adams and colleagues (2005) examined the effect of social desirability (using the Marlowe-Crowne scale to determine participants' tendency towards giving a socially desirable answer) on self-reported PA assessments when compared with DLW measurements. They found that the personal trait 'social desirability' was associated with overestimation of PA energy expenditure and durations. It is, therefore, important to select a survey instrument which minimises reporting bias (Adams et al., 2005).

Secondly, an enriched level of detail in time-use surveys allows investigations of PA and SB surveillance over different domains such as household PA and transport PA, or for specific behaviours such as television viewing and computer use (van der Ploeg et al., 2010). The 2006 ATUS was assessed to examine the interaction between time spent in PA and SB on BMI among adults in the United States (Dunton, Berrigan, Ballard-Barbash, Graubard, &

Atienza, 2009). This study focused on four specific behaviours including MVPA in leisure time (e.g., sports and exercise), active transportation (e.g., walking and cycling), SB in leisure time (e.g., watching TV and video games playing), and SB in transportation (e.g., driving in a car). One of the important conclusions from its findings is that there is a distinct interaction between different types of PA and SB in relation to BMI. Leisure MVPA seemed to decrease BMI risk among those spending large amount of time playing video games, but not watching TV. A wide range of different domains available in time-use data permits investigation of the combined effects of varying types of PA and SB, which may result in more accurate and reliable research findings.

Thirdly, national time-use surveys have been conducted in almost the past six decades in more than 85 countries (Deyaert et al., 2017; United Nations Statistics Division, 2018). This provides PA researchers an opportunity to employ national and international time-use data to study trends of PA and SB or compare the allocation of time in these behaviours both within and across countries (van der Ploeg et al., 2010). Most trend studies used prevalence data from PA questionnaires to observe changes in the behaviours over time (Guthold et al., 2018; Hallal et al., 2012; Sallis et al., 2016). To date, some studies have pioneered using time-use data as an alternative method to observe temporal trends in energy expenditure, PA and SB (Archer et al., 2013; Chau et al., 2012; Spinney & Millward, 2014; Spinney, Millward, & Scott, 2011; van der Ploeg et al., 2013). For example, Chau and colleagues (2012) examined SB and changes of the behaviour over time using the Australian Time Use Surveys 1992, 1997 and 2006. Sedentary time was disaggregated in non-occupational SB domains (i.e., SB in education, household, leisure, and transportation). They found that Australian adults spent averagely 62% of their waking hours in non-occupational SB. It was a slight increase of sedentary time between 1997 and 2006 (mean non-occupational SB = 14.9 hours/2 days and 15.1 hours/2 days, respectively). This increase was mainly accounted for sedentary transport and education, while sedentary household and leisure remained unchanged. However, when stratified by leisure-time sedentary activities, time spent using computer in leisure time was almost 30 minutes higher in 2006 than 1997, while other leisure-time sedentary activities (e.g., reading, listening to music) decreased concurrently. This explains why total sedentary leisure time remained stable, even with a significant increase of time in computer use. Although adverse health effects are primarily based on total PA and SB levels, interventions focus on specific domains. Therefore, understanding the behaviours in each domain can facilitate the development of effective interventions (Ng & Popkin, 2012).

It is important to monitor PA and SB at the population level over a longer term because these data allow evaluation of intervention effectiveness. It is also important to track surveillance progress within and across countries, especially in relation to global PA targets. Global data for trends of PA and SB are scarce due to variations of measurements used across studies and countries (Guthold et al., 2018; Ng & Popkin, 2012). The IPAQ and GPAQ were developed and have been widely used in several national and international surveys to monitor PA and SB levels. As a result, recently the data based on these two questionnaires enabled an internationally comparable assessment on global trends of insufficient PA over a 15-year timeframe (Guthold et al., 2018; Hallal et al., 2012; Sallis et al., 2016). However, Ng and Popkin (2012) argued that applying the same MET criteria in the IPAQ and GPAQ instructions to all countries may not be practical as there are so many distinctions in terms of different contexts among different countries (e.g., environments, economic and physical barriers, and technological advancements). With detailed data of activities across key domains over a significant period of time, Ng and Popkin considered time-use data a more sensible option to estimate the changes in major PA domains (i.e., occupation, domestic production, travel, and active leisure) and SB across countries. In their study, they documented time trends across five countries; the United States (1965 – 2009), the United Kingdom (1961 – 2005), China (1991 – 2009), Brazil (2002 – 2007), and India (2000 – 2005). However, due to the availability of data, they incorporated time-use surveys for only two countries—the United States (employing MTUS and ATUS), and the United Kingdom (employing MTUS). For China, they used China Health and Nutrition Surveys; however, this source provides comprehensive level of data comparable to time-use surveys. For Brazil and India, they obtained occupation or economic activities from the United Nations International Labour Organization. All five countries had an upward trend of SB and downward trend of PA, especially in China and Brazil. Occupational PA was the majority of reductions in PA, followed by household and transportation. This was explained by the transition of the society from agriculture to industry and more advancements in technology. This shifting away from movement was projected to continue in 2020 and 2030.

Time-use surveys have the potential to provide as, or more, accurate estimates of the prevalence of PA and SB than other standard self-reported measures used in health surveillance systems (Harvey & Pentland, 1999; Kelly et al., 2015; Tudor-Locke et al., 2007; van der Ploeg et al., 2010). van der Ploeg and colleagues (2010) tested the reliability and validity of the 2006 Australian Bureau of Statistics Time Use Survey, consisting of 2-day diaries, in assessing SB, LPA, and MVPA across different domains. Time-use method has shown good test-retest reliability between the first and second time-use diaries for estimating non-occupational SB, LPA, and MVPA (intraclass correlations 0.74, 0.46, and 0.73, respectively). When compared time-use diaries with accelerometer data, the concurrent validity showed generally moderate to high correlations for non-occupational SB, LPA, and MVPA (Spearman correlations 0.57 – 0.59, 0.27 – 0.39, and 0.45 – 0.69, respectively).

Another study also found that the previous-day recall method, mostly used in time-use surveys, showed high correlations and validity with the objectively measured accelerometer data for assessing PA and SB (Matthews et al., 2013). Notably, the results from this study also suggest that the estimates of PA and SB from the previous-day recall are unbiased with no correlation between age, BMI, or social desirability and reporting errors. A more recent study assessed the validity of time-use data collected from HETUS by using wearable cameras and found no significant difference between the diary and camera data (Kelly et al., 2015). It can be indicative that a time-use survey is a valid and reliable alternative to traditional questionnaire-based measures for PA and SB epidemiological studies. Moreover, the application of time-use data in monitoring population PA and SB may be considered more acceptable, particularly in low- and middle-income countries, where the uptake of new technologies and devices is limited by their high costs (Harms, Berrigan, & Gershuny, 2019; Pedišić & Bauman, 2015).

Efforts have commenced to harmonise time-use data to investigate PA over the past 15 years (Archer et al., 2013; J. Y. Chau et al., 2012; J. E. Spinney & Millward, 2014; J. E. Spinney et al., 2011; van der Ploeg et al., 2013). However, as time-use data do not provide information on intensity levels of recorded activities, pioneering efforts in the use of time-use data was made on explicit PA behaviours such as walking and exercise for their time duration (in minutes) in order to determine sufficient PA participation in the population. For example, Tudor-Locke and colleagues published three studies on national patterns of walking behaviours (e.g., walking for transport, shopping, exercise) by analysing 24-hour diary data from i) the 1997 Australian Bureau of Statistics Time Use Survey; ii) the 1965 – 2003 American Heritage Time Use Study (AHTUS); and iii) the ATUS 2003 – 2005 (Tudor-Locke, Bittman, Merom, & Bauman, 2005; Tudor-Locke & Ham, 2008; Tudor-Locke et al., 2007). Their findings indicate that 24.1% of Australian adults were sufficiently active from all PA (i.e., sports, exercise, all walking) according to the public health guidelines for PA (a minimum of 30 minutes of MPA daily) (Tudor-Locke et al., 2005). In addition, there was a higher prevalence of walking for transport (20%) than walking for exercise (9%) in Australia in 1997, while in the United States in the three comparable survey years, 1985, 2003, and 2005, the prevalence of walking for transport was 3.6%, 14.4%, and 12.5% respectively, and the prevalence of walking for exercise was 2.9%, 5.4%, and 4.8% respectively (Tudor-Locke et al., 2005; Tudor-Locke & Ham, 2008; Tudor-Locke et al., 2007). Both types of walking behaviours of Americans in three survey years were less prevalent than that of Australians in 1997.

Active transport participation among adults in the United Kingdom was also examined using time-use survey data. Adams (2010) used the 2005 United Kingdom Time Use Survey to describe prevalence and socio-demographic correlates of any active transport participation (i.e., walking, jogging or biking for purposes other than enjoyment). The results show that younger adults spent more time in active transport and were more likely to be sufficiently active (having a minimum of 30 minutes of MPA on at least 5 days per week) through active transport alone than their older counterparts. Overall, 18.6% of adults achieved the current government guidelines for sufficient PA through active transport alone, or 67.1% of all those who reported any active transport (J. Adams, 2010). This is substantially higher than the previous report of the prevalence of sufficient PA through walking for transport of 7.3% in Australia in the same survey year (Tudor-Locke et al., 2005). However, by including only those recorded by walking for transport, the Australian study may have underestimated total PA for transportation.

Time-use surveys in Canada have also been utilised to examine various types of PA. Time spent in physical activities for at least 20 minutes in the 2005 Statistics Canada's General Social Survey – Time Use (GSS-TU) was incorporated to measure different PA levels in urban and suburban residents (Turcotte, 2009). From the same survey of 1998, Spinney and colleagues (2009) calculated time budgets of elderly Canadians spent in walking outdoors (or cycling), and in sports or active leisure activity outside home to quantify the impacts of exercise benefits of transport mobility on quality of life. Active transport walking behaviour was analysed in detail (i.e., frequency and length of walking episodes categorised by origins, purposes, destinations, and distance-decay functions for major destinations) among residents of Halifax Regional Municipality, Canada from the Space-Time Activity Research (STAR) survey (Millward, Spinney, & Scott, 2013). The respondents' description of activities from the STAR survey was coded into 188 activities based on 2005 GSS-TU.

Investigation of the relationship between behaviours and health-related outcomes, requires not only activities and their estimates of time duration, but also estimates of activity intensities and their associated metabolic or energy expenditure (Tudor-Locke, Washington, Ainsworth, & Troiano, 2009). The availability of a classification of human physical activities coded with a standardised scheme can facilitate such estimates (Ainsworth et al., 1993). The Compendium of Physical Activities (hereafter called 'the Compendium') is a comprehensive list of daily activities and their corresponding measures of energy expenditure, expressed in METs (Ainsworth et al., 2011; Ainsworth et al., 1993; Ainsworth et al., 2000). The Compendium has been globally used to quantify physical activities by rate of energy expenditure in adults (Ainsworth et al., 2011). The Compendium was designed to provide a coding system that classifies the energy cost of physical activities and facilitate the comparability of activity intensity levels across studies. This system can be specifically useful for analysing PA data collected by diary, recall, or direct observation methods (Ainsworth et al., 1993).

The Compendium was developed in 1989 and first published in 1993. It was updated twice in 2000 and 2011. The activities identified in the Compendium list were obtained from a variety of PA surveys, diaries, records, and occupational task lists (Ainsworth et al., 1993). The second update version contains 821 specific activities, including 216 new activities added to the 2000 version (Ainsworth et al., 2011; Ainsworth et al., 2000). The intensity or energy cost values listed in the Compendium were derived from eight previously published manuscripts that objectively measured energy expenditure based on the type, purpose, and intensity of the activities. These sources included 1) Tecumseh Occupational Questionnaire, 2) Minnesota Leisure Time Physical Activity, 3) 7-day Recall Physical Activity Questionnaire, 4) American Health Foundation's PA list, 5) McArdle, Katch, and Katch's PA list, 6) Passmore and Durnin's energy expenditure list, 7) Bannister and Brown's energy expenditure list, and 8) Howley and Glover's energy expenditure list (Ainsworth et al., 1993). The mean energy expenditure values from these eight sources were used as the representative intensity levels (where needed) and assigned to the activities. If actual measurements of some specific activities were not available from these sources, the estimates were calculated from the energy expenditure of similar types of activities. It should also be noted that the standard intensity codes listed in the Compendium are merely averages and can be applied to general and healthy adults (18 – 65 years old). This may limit the precise energy cost of PA, which varies in individuals with different age, sex, body mass, adiposity, movement capability, geographic and environmental conditions (Ainsworth et al., 2000).

Tudor-Locke and colleagues (2009) was the first group of researchers who pioneered a study of linking the Activity Coding Lexicon from time-use classification with MET codes catalogued in the Compendium. They assigned the Compendium activity codes and MET values to 438 distinct primary activity variables reported in the 2003 ATUS. The ATUS is a nationally representative time-use survey that has been administered by the US Bureau of Labour Statistics every year since 2003 (United Nations Statistics Division, 2018). This linkage allows improved assessment of PA and SB in American adults to capitalise on vast available and future ATUS data (Tudor-Locke et al., 2009). Several studies have consequently used their summary METs assigned to ATUS activities in characterising patterns of PA and SB (Church et al., 2011; Smith, Ng, & Popkin, 2014; Tudor-Locke, Leonardi, Johnson, & Katzmarzyk, 2011), examining associations of PA and SB with BMI (Dunton et al., 2009; Tudor-Locke et al., 2014) and investigating PA in different social and physical settings (Dunton, Berrigan, Ballard-Barbash, Graubard, & Atienza, 2009).

With informative description of the methods used to classify the activity intensities in ATUS data (Tudor-Locke et al., 2009), other classifications for time-use activities can be assigned with the coding scheme of the Compendium using relatively similar process. For example, the

Australian Time Use activities were assigned an intensity classification using the coding method validated in the ATUS (Chau et al., 2012; Espinel, Chau, van der Ploeg, & Merom, 2015; van der Ploeg et al., 2010). The Belgium Time Use Survey, using an activity coding lexicon of 414 activities based on the HETUS guidelines, was harmonised using the similar procedure by Tudor-Locke et al (2009) to assign respondents' MET estimates (van Tienoven et al., 2018). Spinney and colleagues (2011) also linked the Compendium codes with activities reported in the GSS-TU surveys to quantify the proportion of Canadian adults meeting the maintenance levels of PA (at least 60 minutes per day of LPA through VPA) and the enhancement levels of PA (at least 60 minutes per day of MPA through VPA) between 1992, 1998, and 2005. Similarly, Millward and Spinney assigned the Compendium codes to the STAR time diary data to identify the same proportion of the maintenance and enhancement levels of PA along the urban and rural continuum in Halifax, Canada (Millward & Spinney, 2011). The STAR survey was based on the 2005 GSS-TU data with additional 5 activity codes (Millward & Spinney, 2011).

The same group of researchers (Spinney J., Millward H., and Scott D.) capitalised on the developed methods for harmonising the Compendium and GSS-TU coding schemes to further explore time-use data in the application of PA research. They examined total daily aerobic activity (> 3 METs) and reported the top aerobic activities (i.e., household chores, recreational walking, and active transport) among older Canadians using the GSS-TU data collected in 1992, 1998, 2005, and 2010 (Spinney, 2013; Spinney & Millward, 2014). The examination of aerobic activity (≥ 3.5 METs) in all four domains (i.e., occupation, domestic chores, active transport, and leisure) was also conducted in the Canadian population aged 15 and older using the 2010 GSS-TU data (Millward, Spinney, & Scott, 2014). They found 42% of respondents had at least 20 minutes per day of aerobic activity and participation was mostly in the leisure domain, followed by domestic chores, occupation, and active transport. The most recent study that employed the GSS-TU data harmonised with the Compendium codes by Spinney et al (2011) indicated that elderly Canadians who participated in competitive sport were less sedentary than those involved in leisure time PA or those reported physically inactive (Gayman, Fraser-Thomas, Spinney, Stone, & Baker, 2017).

Time-use data have been used in several studies to explore PA and SB activities individually and simultaneously. The intensity categories between time-use surveys can be interpreted differently according to the referring sources and primary outcomes of interest. For instance, based on Canada's Physical Activity Guide to Healthy Active Living, in GSS-TU studies, activity episodes are classified into very light (<2.5 METs), light (2.5-3.9 METs), moderate (4.0-6.0 METs), and vigorous (>6.0 METs) effort levels (Millward & Spinney, 2011; Spinney & Millward, 2010; Spinney et al., 2011), while those episodes are SB (1.0 to 1.5 METs), light

(1.6 to 2.9 METs), moderate (3.0–6.0 METs), and vigorous (6.0 METs) in ATUS survey, based on PA recommendations from the Centre for Disease Control and Prevention and the American College of Sports Medicine (Dunton et al., 2009; Smith et al., 2014; Tudor-Locke, Leonardi, et al., 2011; Tudor-Locke et al., 2009). Although the process of harmonising time-use activities with the Compendium codes is straightforward, there are some difficulties in metabolic coding. Since time-use surveys are not originally developed to study PA and capture physical movement information, notable challenges lie in assigning METs levels to occupational and travel-related activities (Spinney et al., 2011; Tudor-Locke et al., 2009). In time-use surveys, these activities are recorded generally as occupation and travel time, not broken down into specific tasks. Respondents are not asked to give in great detail of specific activities performed in the work domain. The mode of traveling is also not provided in the traveling domain. This lack of detail makes it impossible to link these activities with the Compendium codes without additional linkage.

The information about respondents' occupational status and mode of travel are generally included in time-use questionnaires (Deyaert et al., 2017). These data can be used to refer to important information necessary to assign an intensity variable for occupation and travel items (Deyaert et al., 2017; Tudor-Locke et al., 2009). Once such information is provided, a MET value can be directly assigned to occupational and travel-related activities by using the Compendium (Spinney et al., 2011; Tudor-Locke et al., 2009). However, occupations with particular MET estimates listed in the Compendium are not inclusive or compatible with most international standard occupational classifications (Ainsworth et al., 2011; Deyaert et al., 2017). Alternative occupational classification systems applying MET values are also published and available for further use. Tudor-Locke and colleagues (2011) assigned underlying corresponding MET values using the Tecumseh Occupational Physical Activity Questionnaire (TOPAQ) classification system. MET estimates were assigned to occupation activities performed during a usual workday and based on body position (e.g., sit, stand, and walk) and intensity (i.e., light, moderate, vigorous) (Tudor-Locke, Ainsworth, et al., 2011; Tudor-Locke et al., 2009). The final product was a single summary MET linked to 22 major occupational groups and 509 detailed occupations within the 2002 Census Occupational Classification System. However, with limited detailed information and varying tasks engaged in during work, the summary METs assigned to occupations should be used and interpreted with caution (Spinney et al., 2011; Tudor-Locke, Ainsworth, et al., 2011; Tudor-Locke et al., 2009). The latest study (Deyaert et al., 2017) overcame this issue by developing a replicable procedure using the most detailed occupational information available to link MET values from the Compendium with 436 specific occupations. They used the 2008 International Standard Classification of Occupations (ISCO) which is considered a complete overview of all occupations with detailed description of all job-specific tasks. In addition, the 2008 ISCO was designed with structure that all occupations can be assigned to one of the Unit Groups, thereby enabling MET calculations to occupations worldwide (Deyaert et al., 2017).

It should also be noted that although harmonising time-use data into the spectrum of movement-related behaviours may facilitate future PA and SB studies, utilising these data may also pose some challenges. As time-use surveys are generally conducted as a population surveillance, not an assessment of physical behaviours, major limitations lie in the generalisation and simplification of time-use activities (Ng & Popkin, 2012; van der Ploeg et al., 2010). The nature of human activities are complex and could be heterogeneous (Ng & Popkin, 2012). The measures of assigning these activities into intensity levels may lead to misclassifications. Not only occupational and travel-related activities that require special treatments when classified, several time-use activities are quite generalised. For instance, in the Trial ICATUS respondents are asked to record time in the activity group '*looking for work in primary production activities in household enterprise'* (Statistical Division United Nations, 2005). Such activities include a wide range of corresponding activities and variations in intensities. This may result in over or under representation of behaviours. Special attention should also be made to activities with light intensity. These activities may be a combination of two different intensities between SB and MPA. This may also explain the low validity correlations of light-intensity activities when compared between time-use diaries and accelerometer data (van der Ploeg et al., 2010).

Furthermore, most time-use surveys gather 24-hour activities for a relatively short assessment period of time, most just one or two days. The Australian Time Use Surveys record population's daily activities over two consecutive days (Chau et al., 2012), while in the American and Canadian surveys, participants provide their personal time use of the previous day (Spinney et al., 2011; Tudor-Locke et al., 2009). It is, therefore, sensitive to individual changes in behaviours between observed and non-observed days. Nevertheless, with large sample sizes of most time-use surveys and the proportionate distribution of data collections over both weekdays and weekends (Tudor-Locke et al., 2009) or all seven days of the week or even over all 12 months of the year (Chau et al., 2012; Spinney et al., 2011), this would balance out individual behavioural misclassifications (van der Ploeg et al., 2010). The short period of recording time would also be limited when analyses are based on the weekly frequency (e.g., PA recommendations of a minimum of 30 minutes for at least 5 days per week). The estimates should, then, be determined according to the available time-use data.

To date, only time-use surveys conducted in high-income countries have been explored in the study of PA and public health concerns. Table 2.1 summarises the studies that employ time-use data in PA and/or SB research. These studies are based on a comprehensive search through reference lists, Google Scholar and Scopus databases. All previous studies integrated their own time-use classification. The international time-use classification adopted in low- and middle-income countries such as ICATUS has barely been examined. It could be a potential benefit of ICATUS to be further assessed and become another valuable resource for PA and SB research. In Thailand, the National Time Use Survey has been conducted using ICATUS since 2001, and subsequent surveys occurred in 2004, 2009, and 2015. With the availability of time-use data across this 15-year period in the Thai population, this could be another opportunity to track long-term PA and SB patterns.

Table 2. 1 Summary of the studies utilising time-use data to examine PA and/or SB

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
Tudor-Locke et al. (2005)	Australia	1997 Australian Time Use survey	7,247 participants (aged 15 and over)	Walking for transport, walking for exercise, and sports/exercise	15% of participants reported sports/exercise participation, providing the most accumulated minutes of PA (72 min/bout), followed by walking for exercise (9% and 47 min/bout), and walking for transport (20% and 12.5 min/bout).
van der Ploeg et al. (2010)	Australia	2006 Australian Time Use survey	134 adults in the Australian state of New South Wales (aged 18 years and over)	SB, LPA, MVPA in occupation, household, transport, and leisure domains	Time-use data showed reliability intraclass correlations 0.74 for non-occupational SB and 0.73 for MVPA, and Spearman correlations of 0.57 for non-occupational SB and 0.59 for MVPA when compared with accelerometer.

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
J. Y. Chau et al. (2012)	Australia	1992, 1997, and 2006 Australian Time Use survey	Population representative data (aged 20 years and over)	SB in non-occupational activities	Non-occupational SB had slightly increased in 2006 from 1997 among Australian adults. This increase was largely due to SB in transport and education time. SB in household and leisure domains stayed unchanged.
Espinel et al. (2015)	Australia	2006 Australian Time Use survey	992 non-working older adults (aged ≥65 years)	SB, LPA, MVPA in household, transport, and leisure domains	About 85% of participants achieved recommended level of MVPA by all domains. They spent 223 min/day in LPA and 121 min/day in MVPA. One third of them spent ≥600 min/day in SB. Neither age nor socio-economic factors were associated with insufficient MVPA.

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
van Tienoven et al. (2018)	Belgium	2013 Belgian Time Use Survey and 2008 HETUS classification	1,458 participants (aged 10 years and over)	Occupational PA and non-occupational PA (i.e. household, transport, and leisure domains)	No association was found between occupational PA and PA in leisure time, household, and transport on weekdays after controlling for socio-demographic variables, except for women in household domain.
Weenas, van Tienoven, Verbeylen, Minnen, and Glorieux (2019)	Belgium	Flanders Modular Online Time Use Survey (MOTUS)	3,028 participants (aged 18 – 64 years)	Meeting WHO guidelines of PA (at least 150 minutes or 300 minutes of MPA per week)	Men were more likely to meet both WHO guidelines of 150 minutes (83.3%) and 300 minutes (71.6%) than women (79.9% and 59.1% respectively). The results showed higher compliance to the WHO guideline of 150 minutes of MPA than previous studies in the Belgian region of Flanders.
Turcotte (2009)	Canada	2005 GSS-TU	Population representative data	Meeting recommended level of	There was no significant difference in the proportion of people meeting

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
			(aged 15 years and over)	PA (at least 20 minutes of activity)	the PA recommendation between low-density and high-density neighbourhoods. Residents of urban neighbourhoods were more active in transportation, while those in suburban areas were more active in household works.
J. E. Spinney et al. (2009)	Canada	1998 GSS-TU	Non-working older Canadian population (aged 65 years and over)	Sports, PA in leisure time and transport	The declining pattern was found with increasing age and time spent in exercise benefits of transport mobility (i.e. sports, PA in leisure time and transport). Women were exposed to 35% fewer exercise benefits. Exposure to exercise was positively associated with increasing satisfaction with life, health, and main activities.

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
J. Spinney and Millward (2010)	Canada	2005 GSS-TU	Population representative data (aged 15 years and over)	MVPA in structured and unstructured leisure, household, and walking and biking	Both income and time poverty were significantly associated with MVPA in all domains. Lower income and time resources had lower engagement in structured and unstructured leisure MVPA. The income rich and time poor had higher participation in household chores, while time wealth and income poor appeared to spend more time walking and biking than their counterparts.
J. E. Spinney et al. (2011)	Canada	1992, 1998, and 2005 GSS-TU	Canadian population (aged 15 years and over)	Meeting maintenance levels of PA (at least 60 minutes per day of LPA through VPA) and enhancement levels of PA (at least	Canadians meeting maintenance levels of PA had increased between 1992 (76.2%), 1998 (77.3%), and 2005 (82.5%), while enhancement levels of PA had decreased over the

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
				60 minutes per day of MPA through VPA)	same time periods (38.1%, 36.6%, and 30.6%, respectively).
Millward and Spinney (2011)	Canada	STAR time diary survey (based on 2005 GSS-TU)	1,971 participants in Halifax, Nova Scotia (aged 15 and over)	Meeting maintenance levels of PA (at least 60 minutes per day of LPA through VPA) and enhancement levels of PA (at least 60 minutes per day of MPA through VPA)	The maintenance and enhancement levels of PA were lowest in suburbs (74.3% for maintenance level and 25.2% for enhancement level) and highest in outer commuter belt (80.3% and 29.0%, respectively).
J. E. Spinney (2013)	Canada	1992, 1998, 2005 and 2010 GSS-TU	Older Canadian population (aged 65 years and over)	Aerobic activity (>3 METs)	Over the past three decades, the most frequently reported aerobic activities among older Canadians were domestic chores (15% to 30% participation for about 2 hrs/day), recreational walking (15% to 30% participation for about 1 hr/day), and

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
					active transportation (< 5% participation for < 30 min/day).
Millward et al. (2013)	Canada	2007-2008 STAR time diary survey (based on 2005 GSS-TU)	Participants in Halifax, Nova Scotia (aged 15 and over)	Walking for transport and recreation	Walking for transport was faster, but shorter in time and duration than recreational walks. Home was the most common origin and destination for transport walking.
J. E. Spinney and Millward (2014)	Canada	1992, 1998, 2005 and 2010 GSS-TU	Older Canadian population (aged 65 years and over)	Meeting PA guidelines for older adults (MVPA in bouts of at least 10 minutes for a minimum of 150 min/week, which averages of 21 min/day)	Older Canadians who met the recommended level of PA were stable (41.1% in 1992, 40.6% in 1998, 43.5% in 2005, and 39.6% in 2010). All four survey cycles demonstrated a declining trend of active living in older Canadians.

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
Millward et al. (2014)	Canada	2010 GSS-TU	15,390 participants (aged 15 years and over)	Aerobic activity (>3.5 METs)	Only 42% of participants reported at least 20 min/day of aerobic activity. Aerobic participation was highest in leisure domain (24.4%), followed by household chores (13.7%), paid work (9.2%), and active transport (4.5%).
Lachapelle and Pinto (2016)	Canada	2005 GSS-TU	Canadian population (aged 15 years and over)	Meeting PA guidelines of at least 30 minutes of MPA through walking	Transit users walked more and met PA guidelines of 30 minutes through walking more than non-users of public transit. However, when specified by purposes of walking, no difference between transit users and non-users.
Gayman et al. (2017)	Canada	2010 GSS-TU	1,723 participants (aged 65 years and over)	PA and SB in leisure time	Respondents who reported leisure PA had the highest PA in leisure time, followed by non-competitive

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
					sport participants, competitive sport participants, and inactive respondents. Competitive sport participants had the least time in SB compared to those who participated in leisure PA and inactive respondents.
van der Ploeg et al. (2013)	Netherlands	The National Time Use Survey of the Netherlands between 1975 and 2005	Dutch adults (aged 20 and over)	Non-occupational SB (i.e., leisure, transport, household, education, and voluntary work domains)	Between 1975 and 2005, Dutch adults spent time in non-occupational SB remained stable at 60%. The decrease in SB was observed in leisure time, from 90% in 1975 to 84% in 2005. However, sedentary time increased by 2 hours per week in transport domain.
Loyen, Chau, Jelsma, van	Netherlands	2006 Dutch Time Use Survey and	1,614 participants (aged 18 and over)	Non-occupational SB (i.e., household,	Dutch adults spent 8 hours (61%) of their daily waking non-occupational time on sedentary activities. Almost

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
Nassau, and van der Ploeg (2019)		HETUS classification		leisure, and transport domains)	90% of their leisure time and 70% on transport were spent sedentary. The higher SB was associated with being male, aged 18-34 and 65 and older, having full-time job and obesity.
J. Adams (2010)	UK	2005 UK Time Use Survey	3,933 participants (aged 16 and over)	Active transport	28% of participants reported any active transport and 19% were sufficiently active through active transportation.
Tudor-Locke et al. (2007)	U.S.A	1965 – 2003 AHTUS including 1) Americans' Use of Time, part of Multinational Comparative Time Budget Research (1965–66); 2)	American population (aged 18 and over)	Walking behaviours and sports/exercise	PA trends could not be concluded according to inconsistencies in instrument administration among different surveys. The prevalence of walking raged from 2.4% in 1965 to 18.9% in 2003, and 21% in 1992-1994. Walking for exercise was highest in 2003. Walking for

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
		University of Michigan Time Use in Economic and Social Accounts (1975–76); 3) University of Michigan Americans' Use of Time (1985); 4) US Environmental Protection Agency National Human Activity Pattern Survey (1992–94); and, 5) ATUS (2003)			transport was higher during 1992-1994 compared to 1985 and 2003. Sports/exercise increased from 1965 to 1985, and remained stable in 1992-1994, and then decreased in 2003.
Tudor-Locke and Ham (2008)	U.S.A	2003 to 2005 ATUS	34,693 participants (aged 15 and over)	Walking behaviours	45.8% of Americans had an average of 45 minutes of walking activities per day in 2003 to 2005.

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
					31.6% walked for shopping, 12.5% for transportation, 4.8% for exercise, and 2.5% for walking the dog.
Tudor-Locke et al. (2009)	U.S.A	2003 ATUS	n/a	Primary ATUS activity variable	The summary MET values were assigned to 438 ATUS 6-digit primary activity codes.
G. Dunton et al. (2009)	U.S.A	2006 ATUS	10,984 non-underweight adults (aged 21 years and over)	Time spent in MVPA and SB activities (in leisure and transport domains) and BMI	More time spent in MVPA at leisure time and transportation and reading were independently associated with lower BMI, while more time in TV watching/computer use and sedentary transportation were independently related to higher BMI.
G. F. Dunton et al. (2009)	U.S.A	2003 to 2006 ATUS	7,700 adults reporting one or more exercise bouts	Recreational exercise and sports bouts in intensity (moderate	70.4% of sports and exercise bouts were moderate-intensity, and 29.6% were vigorous. Vigorous-intensity exercise was more likely when

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
			(aged 21 years and over)	and vigorous) and duration	occurred alone than with other social situations; however, exercise bouts were shorter when performed alone for both intensities.
Tudor-Locke, Ainsworth, et al. (2011)	U.S.A	2003 ATUS	5,289 participants reporting working 6+ hours (aged 15 years and over)	Occupational PA	The detailed and summary MET values were assigned to 509 occupations listed in the 2002 Census Occupational Classification System. The resulting METs show that 78% (based on detailed estimates vs. 88% based on summary estimates) of American workers were employed in sedentary or light-intensity occupations in 2003.

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
Tudor-Locke, Leonardi, et al. (2011)	U.S.A	2003 to 2009 ATUS	Working population (aged 15 years and over)	PA and SB on working days	Americans spent approximately 4.2 hours, 3.8 hours, 35 minutes, and 4 minutes of the day in SB, LPA, MPA, and VPA, respectively.
Archer et al. (2013)	U.S.A	1965 – 2010 AHTUS	American women aged 19 – 64 years	PA in household and leisure, and screen time (TV and computer use)	There was a significant decline of 12.4 hr/week in household PA for women from 1965 to 2010. On the other hand, there was a significant increment in screen time among women, from 8.3 hr/week in 1965 to 16.5 hr/week in 2010. Leisure time PA was also increased from 1.1 hr/week in 1965 to 2.3 hr/week in 2010.
Smith et al. (2014)	U.S.A	2003 to 2012 ATUS	28,437 full-time employed adults	Non-labour market time use and meeting PA recommendations	Both male and female respondents characterised by screen activities, sedentary leisure, and community

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
			(aged 18-65 years), in sedentary jobs	(reporting ≥30 min in activities with >3 MET-h)	patterns were less likely to meet PA recommendations, while those in exercise group was mostly found achieving PA recommendations (≥79%). The screen pattern was the most common (≥120 min/day) and increased from 2003 to 2012 by 10% and 6% for men and women, respectively.
Tudor-Locke et al. (2014)	U.S.A	2006 to 2008 ATUS	4,092 full-time employed adults (aged 20-64 years)	BMI and SB/non-SB occupations	No association was found between BMI and SB or non-SB occupations after accounting for sex, age, race, income, and reported time spent in sleep, non-occupational SB, LPA, MPA, and VPA.
Ng and Popkin (2012)	U.S.A and UK	1961, 1965, 1974, 1975, 1983, 1985, 1987, 1992, 1995,	US and UK adults (aged 18 and over)	PA in occupation, home production,	Total PA levels (all domains combined) were low and declined during 1961 to 2009 and will

Author, publication year	Country/data source	Time-use survey/ classification	Study sample	Main outcome variable	Main results
		1998, 2000, 2005, MTUS and 2003 to 2009 ATUS		travel, and active leisure, SB	continue on downward trend, while SB will continue to rise.
Harms et al. (2019)	U.S.A, UK, and Poland	MTUS; U.S.A (2003-2013), UK (2001) and Poland (2012), the latter two being HETUS compliant	US, UK, and Polish adult populations	PA energy expenditure	The PA level values were 1.59 in the US, 1.62 in the UK, and 1.74 in Poland. Discretionary PA accounted for around 3% of adult daily activity, while the remaining time was spent for one third each in sleep, paid work, and unpaid work or leisure time in the three countries.
Deyaert et al. (2017)	n/a	2008 ISCO	n/a	Occupational PA	The averaging MET values were assigned to 436 occupations listed in the 2008 ISCO.

Legend: based on a comprehensive search of the literature in Google Scholar, Scopus and reference lists of previous papers

The 24-hour Movement Guidelines

Time-use data provide a valuable input into the study of PA and SB surveillance. These data can also support research using the new public health 24-hour movement guidelines that integrate recommendations for PA, SB, and sleep. To date, some countries have updated their PA guidelines to be inclusive of all movement behaviours including sleep, SB and PA. Canada, New Zealand, and Australia, issued the first national guidelines for 24-hour movement and non-movement behaviours, including joint recommendations on sleep, SB, and PA (i.e. the full 24-hr day) (New Zealand Ministry of Health, 2017; Okely et al., 2017; Tremblay et al., 2016; Tremblay et al., 2017). The Canadian 24-hour Movement Guidelines for Children and Youth (aged 5 – 17 years): an Integration of Physical Activity, Sedentary Behaviour, and Sleep were developed in June 2016 and are the first comprehensive guidelines developed by adopting the time-use epidemiology paradigm (Tremblay et al., 2016). A series of four systematic reviews, consultations, and background research including the novel compositional analysis study by Carson, Tremblay, Chaput, and Chastin (2016) were included in the development process of the guidelines. The new Canadian 24-hour movement recommendations including i) ≥60 minutes/day of MVPA; ii) ≤2 hour/day of screen time; and iii) uninterrupted sleep of 9 – 11 hour/night (5 – 13 years old) or 8 – 10 hour/night (14 – 17 years old) (Tremblay et al., 2016) were explored in both Canadian and non-Canadian children and adolescents.

New Zealand updated and replaced the 2007 New Zealand Physical Activity Guidelines for Children and Young People by the 24-hour integrated Canadian recommendations for school-aged children and young people (aged 5 to 17 years) (New Zealand Ministry of Health, 2017). Similar guidelines have now been established for children aged 0 – 4 years in Canada (Tremblay et al., 2017). The guidelines provide recommendations for light-intensity, moderate-intensity, and vigorous-intensity PA, SB, and sleep for infants (<1 year), toddlers (1 – 2 years), and pre-schoolers (3 – 4 years). Australia adopted the Canadian recommendations and updated the first Australian 24-hour Movement Guidelines for the early years (birth to 5 years): an Integration of Physical Activity, Sedentary Behaviour, and Sleep (Okely et al., 2017). In April 2019, WHO launched the first global Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children under 5 years of age (World Health Organization, 2019). These new guidance set how long very young children should be restrained from sitting and watching screens (not more than 1 hour) (Okely et al., 2017; Tremblay et al., 2017; World Health Organization, 2019). They also include recommendations on how long very young children should spend in PA and sleep at different ages. For infants (<1 year), it is recommended that they should be physically active several times a day and have 14 – 17 hour (0 – 3 months of age) or 12 – 16 hour (4 – 11 months of age) of good quality sleep including naps (Okely et al., 2017; Tremblay et al., 2017; World Health Organization, 2019). For toddlers

(1 – 2 years), they should spend at least 180 minutes of PA at any intensities and sleep 11 – 14 hours per night (Okely et al., 2017; Tremblay et al., 2017; World Health Organization, 2019). For pre-schoolers (3 – 4 years or 3 – 5 years for Australian guidelines), they should spend at least 180 minutes of PA, of which at least 60 minutes of MVPA, engage in no more than 1 hour of sedentary screen time, and have 10 – 13 hours of sleep (Okely et al., 2017; Tremblay et al., 2017; World Health Organization, 2019). These guidelines intend to develop movement competence, prevent obesity and optimize children's health now and in later life (World Health Organization, 2019).

Finland and South Africa recently launched the national 24-hour movement guidelines (Draper et al., 2020; UKK Institute for Health Promotion Research, 2019), while Croatia and the United Kingdom have started the process of combining recommendations for a 24-hour day in their guidelines (Jurakic & Pedisic, 2019; Reilly et al., 2020).

Thailand also published the 24-hour movement guidelines in 2017 (Khamput et al., 2017); however, no research have been conducted using or exploring the new guidelines. The Thailand 24-hour movement guidelines include integrated recommendations for five different groups; i) pregnant and postpartum women; ii) early years (birth to 5 years); iii) school-aged children and adolescents (6 – 17 years); iv) adults (18 – 59 years); and v) older adults (60 years and older). In brief, the guidelines include the following recommendations: <u>For pregnant and postpartum women</u>, i) at least 150 minutes/week of MPA, or 75 minutes/week of VPA, or an equivalent combination of the two PA intensities; ii) interrupt SB every 1 – 2 hours; and iii) sleep of 7 – 9 hours/night; <u>For under 5-year children</u>, i) at least 180 minutes/day of PA; ii) interrupt SB every 1 – 2 hours (except during sleep); iii) no screen time (for under 2 years of age) or 15 – 30 minutes/day (for 2 – 3 years of age) or 30 – 60 minutes/day (for 3 – 5 years of age); iv) sleep of 14 – 17 hours (for under 3 months of age) or 12 – 15 hours (for 4 – 12 months of age) or 11 – 14 hours (for 1 – 2 years of age) or 10 – 13 hours (for 3 – 5 years of age); <u>For children and adolescents</u>, i) at least 60 minutes/day of MVPA; ii) ≤2 hour/day of screen time; and iii) sleep of 9 – 11 hour/night (for 6 – 14 years of age) or 8 – 10 hour/night (for 15 – 17 years of age); <u>For adults</u>, i) at least 150 minutes/week of MPA, or 75 minutes/week of VPA, or an equivalent combination of the two PA intensities; ii) interrupt SB every 2 hours; and 3) sleep of 7 – 9 hours/night; <u>For older adults</u>, i) at least 150 minutes/week of MPA, or 75 minutes/week of VPA, or an equivalent combination of the two PA intensities; ii) interrupt SB every 1 – 2 hours; and iii) sleep of 7 – 8 hours/night. Other countries including South Africa and Finland recently adopted the 24-hour movement guidelines, while a few more countries such as Croatia and the United Kingdom also started the process to adopt the integrative guidelines (Draper et al., 2020; Jurakic & Pedisic, 2019; Reilly et al., 2020; UKK Institute for Health Promotion Research, 2019).

Research on 24-hour Movement Behaviours and Health

Emerging evidence suggests that combinations of sufficient PA, low SB, and adequate sleep are beneficial to a range of health outcomes. Chastin and colleagues (2015) examined combined effects of time spent in PA, SB, and sleep on obesity and cardio-metabolic health markers in American adults. Carson et al. (2016) utilised a nationally representative population of Canadian children and adolescents (6 – 17 years). Both studies reported that the combination of all behaviours was significantly related to most obesity and cardio-metabolic health markers (i.e., BMI, waist circumference, triglycerides, blood pressure, C-reactive protein and plasma insulin). MVPA was favourably associated with cardio-metabolic risks (Carson et al., 2016; Chastin, Palarea-Albaladejo, et al., 2015). When taking other behaviours into account, SB and LPA were associated with higher BMI, while MVPA and sleep were associated with lower BMI in both American adults and Canadian children and youth. More time in SB and less time in sleep, LPA, and MVPA were found in the lowest aerobic fitness group of Canadian children and youth. Less time in SB and more time in sleep, LPA, and MVPA were observed in the lowest waist circumference group of Canadian children and youth. For American adults, only SB ($B = 2.41$, $p = 0.023$) and MVPA ($B = -2.96$, $p<0.001$) were significantly associated with waist circumference.

Collectively, previous studies suggest that the whole composition of 24-hour movement behaviours is positively associated with health in children, adolescents, adults, and older adults (Biddle et al., 2018; Dumuid et al., 2018; Dumuid et al., 2017; Dumuid et al., 2018; Dumuid et al., 2019; Gupta et al., 2019; McGregor et al., 2018). The new 24-hour movement guidelines combine evidence-based recommendations for these key behaviours of PA, SB, and sleep into comprehensive public health guidelines (Tremblay et al., 2016). Since the release of the new guidelines in several countries, recent studies have investigated the relationships between meeting these new public health benchmarks and health. Carson and colleagues (2017) examined the adherence to the new guidelines with obesity and cardio-metabolic health markers. They found that meeting more individual-behaviour recommendations was associated with better overall health among Canadian children and adolescents (Carson et al., 2017).

Other important facets of mental health and psychological indicators were also explored in relation to meeting the 24-hour movement guidelines. Better psychosocial health (i.e. emotional problems, life satisfaction, and prosocial behaviour) was found for Canadian adolescents meeting several individual-behaviour recommendations (Janssen, Roberts, & Thompson, 2017). Similarly, psychological well-being was favourably associated with more frequent participation in PA and sleep in South Korean adolescents (Lee, Spence, Tremblay,

& Carson, 2018). One study examined associations between health-related quality of life and combinations of movement recommendations in children in Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the United Kingdom, and the United States (Sampasa-Kanyinga et al., 2017). They found higher health-related quality of life among children who met the guidelines (health-related quality of life T-score of 51.2 in participants meeting all three recommendations compared to 49.6 in participants meeting no recommendation). However, the association varied between sexes and countries. For example, children in Australia, Canada, and the United States reported better health-related quality of life when meeting all three recommendations, while children in Kenya and Portugal reported significantly lower health-related quality of life when meeting all three recommendations. Therefore, it is important to consider country-specific contexts when developing public health interventions to improve the movement behaviours (Sampasa-Kanyinga et al., 2017).

The current literature, although still limited, has illustrated that prevalence of meeting the 24-hour movement guidelines is low in all age groups. A total of 14.9% of pre-schoolers met the new Australian 24-Hour Movement Guidelines for the Early Years (Cliff et al., 2017) and 12.7% of pre-school aged children in Canada met the guidelines (Chaput et al., 2017). Much lower proportions of Belgian pre-school children met all 24-hour movement recommendations (5.6% overall; 10.1% on weekdays; 4.3% on weekends; De Craemer, McGregor, Androutsos, Manios, & Cardon, 2018). By contrast, a large proportion of pre-schoolers from all three countries met the sleep recommendation (88.7% Australia; 83.9% Canada; 94.0% Belgium). While Australian and Canadian young children had high compliance with PA guidelines (93.1% Australia; 61.8% Canada) and low with SB (17.3% Australia; 24.4% Canada), Belgian children had opposite patterns of 11.0% adherence with PA and 47.2% adherence with SB recommendations.

A total of 17.1% Canadian children and adolescents met the 24-hour movement guidelines (Carson et al., 2017), while Lee and colleagues found only 1.6% of South Korean adolescents meet the guidelines (Lee et al., 2018). A study conducted in 12 countries across major world regions also found only 7.2% of 9 to 11-year-old children met all MVPA, screen time, and sleep recommendations (Sampasa-Kanyinga et al., 2017). For young and older adults, Lee and colleagues examined the proportion of South Korean adults and older adults who had at least 600 MET-minutes/week of MVPA, sat less than 9 hours/day, and slept 7 – 9 hours/day (for adults) or 7 – 8 hours/day (for older adults; Lee et al., 2019). They found only 0.4% of adults and no older adults met these combined recommendations.

Although the current evidence is limited, these preliminary findings of low guideline compliance suggest the need for effective public health interventions promoting a healthy balance of all 24-hour movement behaviours and regular monitoring of the 24-hour movement guidelines at the country level.

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CHAPTER III: Methodology and Procedures

The aims of the PhD were to provide a comprehensive summary of physical activity (PA) and sedentary behaviour (SB) research and understanding of the prevalence, trends, and correlates of the behaviours in Thailand. To achieve these aims, this PhD includes five studies using five different research designs. The aim of this chapter is to provide an overview of the methodology, core rationale and concepts used in or across five studies. Research designs applied specifically for each study are presented in this chapter in addition to the method section embedded in each of the respective papers. Theoretical and conceptual frameworks that underpin this thesis are also described.

Research Framework

This PhD thesis is structured under an umbrella of behavioural epidemiology framework (Sallis, Owen, & Fotheringham, 2000) where the patterns of the behaviours and evidence needed to facilitate the development of public health initiatives to improve PA and SB in Thailand were built throughout the five studies. This includes, but is not limited to, systematically reviewing evidence of PA and SB research in Thailand (study one), measuring PA and SB behaviours (study two); identifying influences of PA and SB (study three); and characterising prevalence and variations of PA and SB in Thailand (study five) (Mabry, Koohsari, Bull, & Owen, 2016; Sallis, Owen, et al., 2000). This research also recognises the time-use properties of PA and SB behaviours and was, therefore, guided by the concepts of time-use epidemiology, a field of research that is conceptually a part of behavioural epidemiology (Pedišić, Dumuid, & S Olds, 2017). Figure 3.1 shows the relationship between behavioural epidemiology, time-use epidemiology, and other previously established epidemiological disciplines (Pedišić et al., 2017).

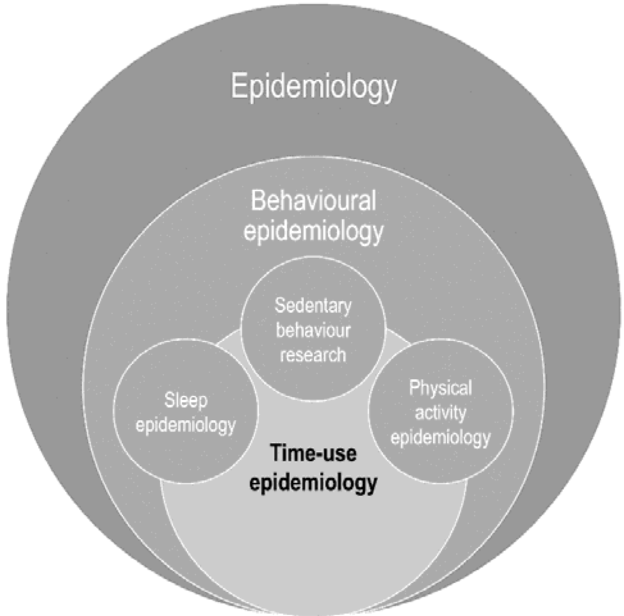

Figure 3. 1 Relationship between time-use epidemiology and previously established epidemiological disciplines (taken with permission from Pedišić et al. (2017))

Time-use Epidemiology

Time-use epidemiology is a young multidisciplinary field of study that commonly investigates three movement and non-movement behaviours (i.e., PA, SB, and sleep) in relation to health outcomes (Pedišić et al., 2017). It is a growing field of study where compositional properties of time-use data have been recognised and acknowledged by using the respective statistical approach. The concept of time-use epidemiology has recently been examined in some studies (Carson, Tremblay, Chaput, & Chastin, 2016; Chaput, Saunders, & Carson, 2017; Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015; Rosenberger, Buman, Haskell, McConnell, & Carstensen, 2016; Saunders et al., 2016).

The concept has also been emphasised and integrated in the public health guidelines in some countries, including Canada, Australia, New Zealand, Thailand, South Africa, Finland, Croatia and the United Kingdom. Canada was the first country acknowledging the integrative compositions of 24-hour movement behaviours and developed the Canadian national recommendations based on an integration of sleep, SB, and PA for the early years (0 – 4 years), children and youth (5 – 17 years) (Tremblay et al., 2016; Tremblay et al., 2017). Australia adapted the Canadian 24-hour guidelines and has now developed its own comprehensive guidelines for the early years (0 – 5 years) (Okely et al., 2017). New Zealand also updated its guidelines for children and young people (5 – 17 years) based on the Canadian 24-hour movement recommendations for this age group (New Zealand Ministry of

Health, 2017). Recently, South Africa, the United Kingdom, and the WHO also issued the 24-hour guidelines for movement behaviours for under five years of age population (Draper et al., 2020; Reilly et al., 2020; World Health Organization, 2019).

For Thailand, the Division of Physical Activity and Health, Ministry of Public Health adopted the 24-hour integration of movement behaviours and published the first Thailand Recommendations on Physical Activity, Non-Sedentary Lifestyles, and Sleeping in 2017 (Khamput et al., 2017). This guideline includes recommendations for five population groups including pregnant and postpartum women; early years (birth to 5 years); school-aged children and adolescents (6 – 17 years); adults (18 – 59 years); and older adults (60 years and older). More countries also tend to update their guidelines to cover 24-hour continuum in the future.

Studies 4 and 5 of this project were based on VIRTUE framework (Figure 3.2) (Pedišić et al., 2017). The central concept of this framework is to acknowledge the compositional properties of time-use components such as sleep, SB, LPA, and MVPA. To provide a full lens of understanding on health-related time-use compositions, the framework delineates epidemiological research through five key research areas: 1) methods; 2) outcomes; 3) prevalence; 4) determinants; and 5) interventions. This thesis addresses three areas from the VIRTUE framework; namely methods (measurement), time-use composition (prevalence and trends), and determinants (socio-demographic).

Movement behaviours are typically measured by a self-report such as GPAQ and IPAQ, or device-based tool such as pedometer and accelerometer. However, with such tools these behaviours have been measured individually. Therefore, there is a need for the development of measurement or improvement in the existing measurement tools to properly assess relative components of time use (Pedišić et al., 2017). In addition, time-use survey data has been validated as an adequate tool for observational studies with comprehensiveness of 24-hour records (van der Ploeg et al., 2010). Study 4, therefore, developed the classification system for the ICATUS, one of the most common time-use surveys collecting 24-hour data in a population, to classify activities in a 24-hour continuum into behaviour compositions. With the adequate measurement of time use from Study 4, the trends and factors associated with the parts of time-use components (i.e., MVPA, SB, and sleep) were determined in Study 5. The VIRTUE framework also incorporates the social ecological approach, which was used as a conceptual framework for Study 3. More details of the studies and their research design are described in the relative sections below.

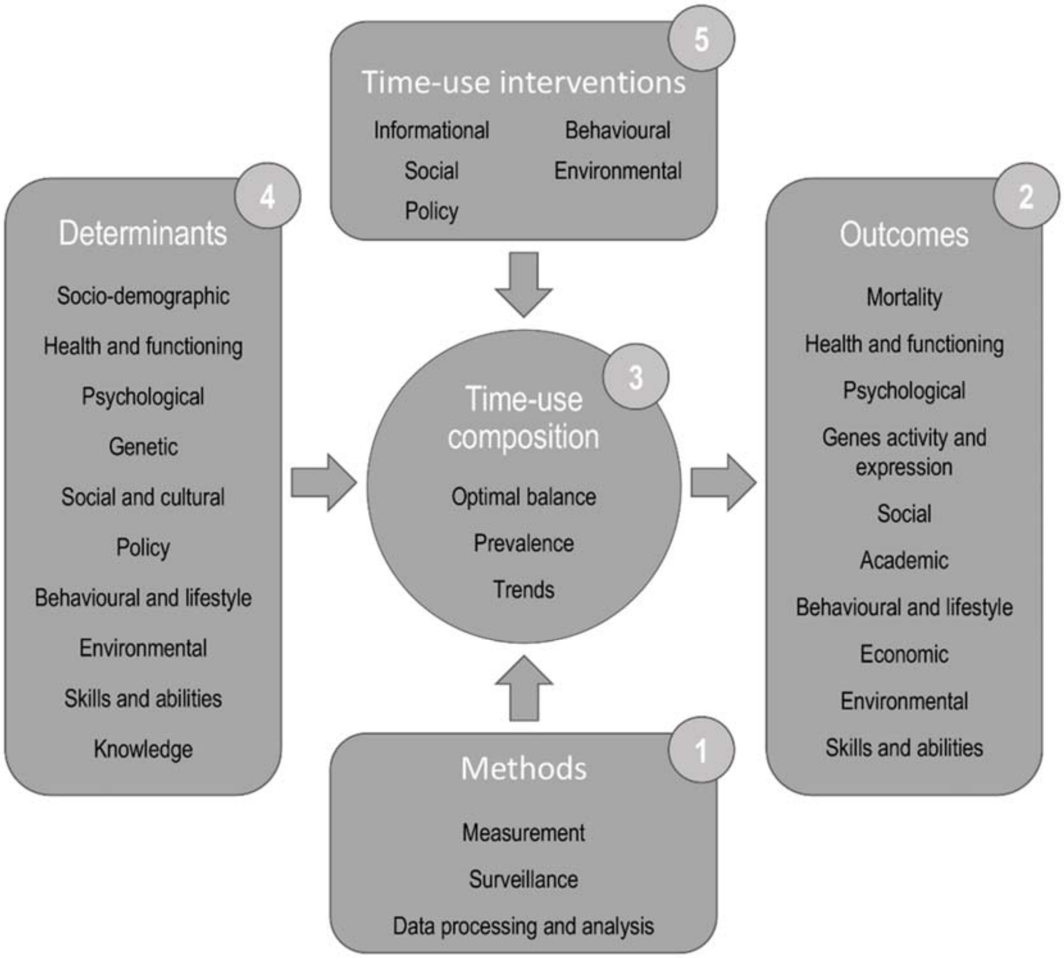

Figure 3. 2 The Framework for Viable Integrative Research in Time-Use Epidemiology – VIRTUE framework (taken with permission from Pedišić et al. (2017))

Study Methods

The five studies embedded in this thesis used the following research methods; a scoping review, a systematic review, a secondary analysis of cross-sectional data, a methodological study, and a secondary analysis of time-use data. By applying these study methods, this project provided a thorough documentation of available literature on PA and SB in Thailand, summarised available evidence on correlates of the behaviours in the Thai population, developed a classification system for classifying the ICATUS activity groups into sleep, SB, LPA, and MVPA categories, and determined levels and correlates of PA and SB and their trends over time. The research method and the theoretical model (if applicable) specifically used in each study are described below.

Study 1: Physical Activity and Sedentary Behaviour Research in Thailand: A Systematic Scoping Review

Liangruenrom N, Suttikasem K, Craike M, Bennie JA, Biddle SJH, Pedisic Z. Physical activity and sedentary behaviour research in Thailand: a systematic scoping review. BMC Public Health. 2018;18(1):733.

A scoping review is a method of evidence-based synthesis, suitable for summarising evidence on broad research questions or topics, regardless of study designs, and evidence mapping in areas where no such comprehensive review has been conducted (Arksey & O'Malley, 2005). A scoping review is a relatively new review type with its first methodological framework published in 2005 (Arksey & O'Malley, 2005; Peters et al., 2015; Pham et al., 2014). However, it has become a common approach for mapping existing literature in a broad area (Peters et al., 2015; Pham et al., 2014). It is also important to highlight some distinctions between a scoping review and a systematic review. For example, the purpose of a scoping review as mentioned above is to map a potentially large and diverse body of literature, whereas a systematic review aims to summarise evidence from a smaller amount of studies and on a specific question (Arksey & O'Malley, 2005; Pham et al., 2014). In addition, the included studies for a scoping review usually derive from a greater range of methodologies than a systematic review (Pham et al., 2014). However, the process of the conduct of a scoping review and a systematic review is similar, involving a systematic search, clarity and transparency (Peters et al., 2015). With its great utility for synthesising large research evidence, a scoping review was a relevant method to systemise the development of PA and SB research in Thailand.

The systematic scoping review was conducted to perform a mapping of research evidence on PA and SB in Thailand. This study also provided an insight into available evidence and gaps in the literature, which allowed for making evidence-based recommendations for future directions in Thai PA and SB research. This scoping review was conducted using the same rigorous and transparent methods as a systematic review (Pham et al., 2014), and aligned with the National Health and Medical Research Council guidelines (Bielemann, Martinez-Mesa, & Gigante, 2013). The systematic search was conducted comprehensively with 44 search keywords through 10 databases from primary search and four main sources of secondary search. The study selection was completed independently and transparently by two researchers to avoid any potential bias. The third researcher was used to resolve discrepancies in the selection results.

Prior conducting the scoping review, a pilot study was carried out to assess the feasibility and to define the search strategy. The total number of search results in the pilot search was 7,456 as shown in Table 3.1.

Table 3. 1 Pilot search results

Bibliographic database	**Search results**
Academic Search Premier	1372
CINAHL	231
Health Source: Nursing/Academic Edition	227
MasterFILE Premier	127
PsycINFO	376
PubMed/MEDLINE	815
Scopus	1838
SPORTDiscus	387
Web of Science	2083
Total	**7456**

A pilot study selection was conducted from the 1,838 search results in Scopus. A total of 99 studies focused on PA and/or SB in Thailand, out of which 55 were population-based studies, 39 were intervention-based studies, and 5 were measurement studies.

From the pilot study, it was concluded that it was feasible to conduct a scoping review of PA and SB research in Thailand. The sample search syntax used in Scopus is as follows:

title-abs-key("physical activity" OR "physical inactivity" OR "physically inactive" OR “physical fitness” OR "energy expenditure" OR exercise OR sport OR gym OR "motor activity" OR walking OR cycling OR stair OR “active travel” OR “active transport” OR sedentar* OR sitting OR "watching TV" OR "TV watching" OR "TV viewing" OR television OR "video watching" OR "watching video" OR "computer use" OR "internet use" OR gaming OR "video games" OR "social media" OR "screen time" OR lifestyle OR "strength training" OR "resistance training" OR "weight training" OR "weight lifting" OR "muscle strengthening" OR "muscular strengthening" OR "muscle training" OR "muscle toning" OR "weight bearing training" OR "weight bearing strengthening" OR "strength or toning" OR "strength/toning" OR "strength / toning" OR "strength and toning") AND title-abs-key(thai*).*

The full search strategy, including keywords and syntaxes specifically used for each database are available in the APPENDIX 1. Other procedures can be found in the paper in Chapter IV.

Study 2: Do Thai People Meet Recommended Physical Activity Level?: the 2015 National Health and Welfare Survey

Liangruenrom N, Topothai T, Topothai C, Suriyawongpaisan W, Limwattananon S, Limwattananon C, et al. Do Thai People Meet Recommended Physical Activity Level?: The 2015 National Health and Welfare Survey. Journal of Health Systems Research. 2017;11(2):205-20.

This study aimed to determine the prevalence of PA and SB in the Thai population. The data from large scale surveys with national representation has high quality information for detailed exploration to generate new knowledge that is important for the research community and policymakers (Tripathy, 2013). This study was based on data from the 2015 Thai National Health and Welfare Survey (HWS) conducted by the National Statistical Office (NSO). The NSO is a state agency responsible for statistical data production for national development. The agency is enacted by the Official Information Act, B.E. 2540 (1997) (National Statistical Office, 2004) and its surveys have been recognised and contributed to population, society, and health research (National Statistical Office, 2016a). The HWS has been conducted since 1974 by the NSO; however, it was the first time that the GPAQ was included in the 2015 HWS to measure PA and SB levels in the largest Thai national survey (National Statistical Office, 2016a). A total of 139,848 participants were interviewed face-to-face, which statistically weighted to represent the total population of 67,163,661 Thais (National Statistical Office, 2016a). The details of the analysis can be found in the paper in Chapter V.

Study 3: Correlates of Physical Activity and sedentary behaviour in the Thai Population: A Systematic Review

Liangruenrom N, Craike M, Biddle SJH, Suttikasem K, Pedisic Z. Correlates of physical activity and sedentary behaviour in the Thai population: a systematic review. BMC Public Health. 2019;19(1):414.

A systematic review involves a comprehensive search strategy with the goal to reduce bias in a study selection (Uman, 2011). Study three used a systematic review method to synthesise all relevant studies on PA and SB correlates in Thailand. The review followed the guidelines of Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA), developed by experienced methodologists to provide a 27-item checklist and a four-phase flow diagram for transparent reporting of the systematic review (Liberati et al., 2009). The PRISMA checklist can be found in the APPENDIX 2, and the diagram is presented in the paper in Chapter VI. Due to great heterogeneity in the measurements of PA and SB and statistical methods used in the included studies, a formal meta-analysis was considered inappropriate for this review

(Verswijveren et al., 2018). This systematic review, therefore, included a statistical component to synthesise the quantitative data of the results by adapting the coding technique proposed by Sallis et al (2000). This coding system has been endorsed in several previously published reviews (Boxberger & Reimers, 2019; Lindsay Smith, Banting, Eime, O'Sullivan, & van Uffelen, 2017; Sallis, Prochaska, & Taylor, 2000; Trost, Owen, Bauman, Sallis, & Brown, 2002; Uijtdewilligen et al., 2011; Verswijveren et al., 2018). The coding rules were applied to classify and summarise the associations between the behaviours and their correlates into i) mostly positive associations (coded as +); ii) mostly negative associations (coded as -); or mostly non-significant, indeterminate or inconsistent associations (coded as ?). The full detail of data pooling and coding are available in the paper in Chapter VI.

Methodological quality of included studies

Another key aspect of the conduct of a systematic review is the risk of bias assessment (Lo, Mertz, & Loeb, 2014). The Cochrane Collaboration has recommended the Newcastle-Ottawa Scale (NOS) as the assessment tool for observational studies (Lo et al., 2014). All studies included in this review used a cross-sectional design; therefore, the NOS assessment was considered suitable for rating the methodological quality of each included study. The NOS tool has been developed through a collaboration between the Universities of Newcastle, Australia and Ottawa, Canada. The scale contains three categories including i) selection (representativeness of the sample; sample size; non-respondents; ascertainment of the risk factor), ii) comparability, and iii) outcome (assessment of the outcome; statistical test) (Wells et al., 2019).

Each study included in this review was given points independently by two researchers according to the scoring rules. The score was used to assess quality of the studies ranging from 0 (lowest quality) to 10 (highest quality). A study with a score of less than 5 was considered as low quality; 5 – 7 as moderate quality; and more than 7 scores as high quality (Gao et al., 2013). The median overall score of the included studies in this review was 6 (‘moderate quality’). Of 167 total studies, 23 were categorised as ‘high quality’, 34 were considered as ‘low quality’, while the remainder were of moderate quality (*n* = 110). Among the high-quality studies, seven studies focused on children and adolescents, seven focused only on adults, two only on older adults, and seven on both younger and older adults. It was, therefore, not purposeful to perform a sensitivity analysis using only findings from high-quality studies.

The quality of the included studies was also assessed by each category of the NOS assessment (i.e., Representativeness of the sample; Sample size; Non-respondents; Ascertainment of the risk factor; Comparability, Assessment of the outcome; and Statistical test). Percentages of the quality was calculated and found the highest score (98.8%) for 'Statistical test' item, followed by 'Ascertainment of the risk factor' (82.3%). The indicator 'Comparability among subjects in different outcome groups' was considered the lowest (16.8%) and needed improvement. Fairly satisfactory scores of 62.9%, 58.7%, and 55.1% were obtained from the indicators 'Assessment of the outcome', 'Representativeness of the sample', and 'Sample size', respectively. The quality of the item 'Non-respondents' was quite unsatisfactory (36.5%). The results of the quality assessment for all the included studies can be found in the APPENDIX 3.

Social Ecological Model as Conceptual Framework

Social ecological models have their origins from the term 'ecology' which broadly refers to the study of the interrelations between organisms and their environments (Stokols, 1992, 1996). The study of ecology has evolved and expanded to several disciplines including social sciences, economics, and public health (Stokols, 1992, 1996). The social ecology concept emerged in the earliest years of the development of health promotion during the mid-1960s and early 1970s when there was a need for guiding frameworks to explain behavioural changes beyond individual and social influences (Elder et al., 2006; Stokols, 1992, 1996). The field of social ecology offers a theoretical framework to understand the dynamic interplay among people's behaviour and their social, institutional, and cultural contexts (Stokols, 1992, 1996). The social ecological framework has become common and been widely adopted in health behaviour research (Elder et al., 2006).

Social ecological models of health behaviour explain the interplay between individual, social and environmental influences (Sallis, Owen, & Fisher, 2008; Stokols, 1996). Sallis and colleagues (2008) propose that one of the core principles of social ecological perspectives on health behaviour change is that multiple levels of factors including intrapersonal, interpersonal, organisational, community, and public policy influence health behaviours. They further indicate that there are interactions and reciprocity among these factors across various levels. Knowledge and understanding of multiple levels of influence is important to guide the development of more comprehensive interventions (Bauman et al., 2012; Sallis et al., 2008). Therefore, the priority is to improve understanding of multi-level correlates and their interactions across levels, and thereby applying the findings to design more effective interventions (Sallis et al., 2008).

In addition, even though the components of the model could be integrated in a wide range of health behaviours and populations, variables in each level may vary across settings (Sallis et al., 2008). Specifically, a social ecology highlights environmental and policy influences which are distinct for different behaviours and population groups. For example, the availability of public transportation and safety of the neighbourhood may influence participation in PA differently in different countries or even between different age groups in the same country. The model, therefore, needs to be specifically contextualised for each behaviour at the national or local level (Sallis et al., 2008). Within the health behaviour focus, social ecological approaches have been adopted as a framework to better understand PA and SB (Bauman et al., 2012; Chastin, Buck, et al., 2015; Giles-Corti & Donovan, 2002; O'donoghue et al., 2016; Sallis, Prochaska, et al., 2000; Trost et al., 2002; Uijtdewilligen et al., 2011). However, only few studies have examined correlates of PA and SB at multiple levels, especially in low- and middle-income countries, including Thailand (Bauman et al., 2012; Chastin, Buck, et al., 2015; Giles-Corti & Donovan, 2002; O'donoghue et al., 2016; Sallis, Prochaska, et al., 2000; Trost et al., 2002; Uijtdewilligen et al., 2011). Thus, this review was based on the social ecological model and aimed to summarise available evidence on individual, social, environmental, and policy-related correlates of PA and SB in Thai children, adolescents, adults, and older adults.

Study 4: Standardised criteria for classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity categories

Liangruenrom N, Craike M, Dumuid D, Biddle SJH, Tudor-Locke C, Ainsworth B, Jalayondeja C, van Tienoven TP, Lachapelle U, Weenas D, Berrigan D, Olds T, Pedisic Z. Standardised criteria for classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity. International Journal of Behavioral Nutrition and Physical Activity. 2019; 16: 106.

This study aimed to develop the standardised criteria including relative energy expenditure (MET estimates), wakefulness status (awake or not awake), and posture (sitting/reclining/lying or other) to classify the ICATUS activities into sleep, SB, LPA, and MVPA categories. The study four and five used the ICATUS data for analysis. The core rationale and basic concepts of the ICATUS data are described below. More detail and other methodological information specifically related to each study are available in the respective papers, Chapters VII and VIII.

Time-use surveys

Time-use surveys have been conducted at national level, starting in developed countries such as the United States, Australia, Japan, Canada, and Norway, since the 1960s (United Nations Statistics Division, 2018; van der Ploeg et al., 2010). The value of time-use information in policy development is increasingly recognised, thus becoming part of social statistics in many developed countries (United Nations Economic Commission for Europe, 2013). In developing countries, time-use surveys were first conducted in the late 1990s, mainly to measure paid and unpaid work dimensions of gender equality (Charmes, 2015). The number of countries collecting time-use data is rising (United Nations Economic Commission for Europe, 2013). In recent years, national time-use surveys have already been implemented in more than 85 countries around the world (United Nations Statistics Division, 2018).

Time-use surveys are designed to collect information on all of the activities that individuals undertake over a 24-hour time period (United Nations Economic Commission for Europe, 2013; United Nations Statistics Division, 2018). Therefore, they gather information on a variety of activities and can address a number of issues. The fundamental areas that can be identified from time-use information include non-paid work and non-market production; well-being (social and leisure time and work-life balance); gender equality; and other applications (e.g., health, work, transport, environment and climate) (United Nations Economic Commission for Europe, 2013). Many national and international time-use classifications have been developed to form an integral component of time-use activities such as American Time Use Study (ATUS), Australian Time Use Activity Classification, Harmonised European Time Use Survey (HETUS), and ICATUS.

International Classification of Activities for Time-Use Statistics (ICATUS)

The ICATUS, one of the most commonly used classifications, has been developed by the United Nations Statistics Division (UNSD) to serve as a standard framework for time-use statistics applicable for both developed and developing countries (United Nations Statistics Division, 2017). Its development is based on the principles of statistical classifications to provide comprehensive measurements and data analysis for addressing a wide range of national and international socioeconomic issues (United Nations Statistics Division, 2017). Concerning the coverage of activities identified in the classification, 91% of ICATUS activity categories can be aggregated into the broad minimum list of activities recommended in the Guidelines for Harmonising Time-Use Surveys. This is higher than that of other classifications such as the Australian Time Use Activity classification (88%), HETUS (86%), and ATUS (78%) (United Nations Economic Commission for Europe, 2013).

Most developed countries developed and use their own classification such as ATUS in the United States, Statistics Canada's General Social Survey – Time Use (GSS-TU) in Canada, and HETUS in European countries. The ICATUS is, therefore, mainly used in developing countries, particularly in Asia and Africa (Charmes, 2015). Since 2001, the NSO (Thailand) has conducted the national time-use survey every four years using the ICATUS (National Statistical Office, 2002). The ICATUS was initially developed as a 'draft' classification in 1997 by the United Nations expert group (United Nations Statistics Division, 2017). The working group carried out a revision and published the Trial ICATUS in the Guide to Producing Statistics on Time Use: Measuring Paid and Unpaid Work (Statistical Division United Nations, 2005). Through several consultations and expert group meetings organised from 2012 to 2016, the finalisation of ICATUS was made available in 2016. It was a long process incorporating comments and suggestions from experts and relevant stakeholders including national statistical offices from 43 countries (United Nations Statistics Division, 2017).

Given the integrated time-use epidemiology paradigm discussed earlier in this Chapter, there is a need to develop a classification system to derive major health-related time-use components (i.e. sleep, SB, LPA, and MVPA) from comprehensive 24-hour time-use data. Such a system has been explored by linking MET values from the Compendium of Physical Activities (Ainsworth et al., 2011) with time-use data in some classifications (i.e., ATUS, HETUS, Australian Time Use Activity Classification, GSS-TU, and Belgian Time Use Survey) (Chau et al., 2012; Millward, Spinney, & Scott, 2014; Smith, Ng, & Popkin, 2014; Spinney, Millward, & Scott, 2011; Tudor-Locke, Washington, Ainsworth, & Troiano, 2009; van Tienoven et al., 2018). However, no such system has been developed for ICATUS activity groups. This study, therefore, conducted a Delphi survey to obtain expert assessments of the Trial ICATUS and the final ICATUS classifications.

Delphi expert evaluation process

The Delphi technique was developed in the 1950s and has been widely used as a data collection methodology in a wide variety of applications including economics, education, civic planning, and public health (Hsu & Sandford, 2007; Linstone & Turoff, 1977; Thangaratinam & Redman, 2005). Linstone and Turoff (1977) defined Delphi as a method for structuring a group interaction process to effectively develop consensus on a complex matter. Delphi has been used to gain collective opinions and judgements from a group of individuals who are well associated with a specified topic (Yousuf, 2007). According to Linstone and Turoff (1977), Delphi is most appropriate as a survey tool when one or more of the following circumstances is addressed:

1) When the problem is broad or complex and needs collective examinations.
2) When the experts from diverse background and experience are needed to solve the problem, but time and cost constraints can be an issue to conduct sufficient face-to-face meetings.
3) When the communication process should be anonymous to avoid sensitive disagreement among the participants.
4) When the heterogeneity of the participants is important to assure validity of the results (Linstone & Turoff, 1977)

It has been suggested that Delphi has been used extensively to address issues where empirical evidence is unavailable by employing the knowledge and experience of experts (Thangaratinam & Redman, 2005). To date, ICATUS data has not been classified into integrated components of movement and non-movement behaviours (sleep, SB, LPA, and MVPA). To obtain the standardised criteria for classifying these time-use activities into a meaningful system, it requires expertise, relevant backgrounds and experience related to the disciplines (i.e., PA, SB, and Time use epidemiology) to achieve such aims. In addition, the Delphi design has basic features that make it more suitable than a conventional survey to address the aims of this study. The main characteristics of Delphi include a series of questionnaires providing opportunities for participants to reflect and/or modify responses; anonymity of responses; controlled feedback allowing interaction among panelists in several stages; and representative opinion of final group responses (Thangaratinam & Redman, 2005; Yousuf, 2007). Given the circumstances, Delphi was considered suitable as the effective research tool for this study.

The process of Delphi includes three important components; a panel of experts, a communication process, and crucial feedback (Yousuf, 2007). In this study, a panel of experts, a communication process, and crucial feedback were identified by adapting key steps of the Delphi procedure proposed in Brooks (1979) and Issac and Michael (1981) (Yousuf, 2007):

<u>A panel of experts</u>

1) *Identifying a group of experts*

The selection of Delphi subjects is the most important step in the process (Hsu & Sandford, 2007). The quality of the study directly relies on a group of participants who contribute their knowledge and experience into the process. There is no exact criterion for a standard set of Delphi participants; however, it is highly recommended that to participate in the Delphi study, participants should be in the disciplinary areas of expertise of the study focus (Hsu & Sandford, 2007; Linstone & Turoff, 1977; Thangaratinam & Redman, 2005; Yousuf, 2007). Concerning the optimal number of Delphi subjects, it is largely pragmatic depending on the study design, and varies in the literature. The approximate size of a Delphi panel is generally under 50, and ranges between 4 and 3000 (Hsu & Sandford, 2007; Thangaratinam & Redman, 2005). A group of seven, or ten to fifteen panellists was also suggested as a sufficient number for a Delphi panel (Hsu & Sandford, 2007; Thangaratinam & Redman, 2005).

To address the aim of this study, to develop standardised criteria to classify the international time use activities into movement and non-movement categories (sleep, SB, LPA, and MVPA), a total of 13 experts in PA, SB, and Time use epidemiology were invited. This included experts in the Compendium of Physical Activities, which was utilised as the main instrument linking the time use activities with the MET values. The experts came from seven different countries, representing diverse backgrounds, including Australia, Belgium, Canada, Croatia, Thailand, the United Kingdom, and the United States. As there are almost 400 ICATUS activities to classify, the experts were divided into four panels to review approximately 90 activities in each group.

2) Assessing the willingness to participate in the Delphi survey of potential panellists

It is essential to ensure understanding of the process by the potential participants before initiating the Delphi study (Yousuf, 2007). The participants were invited to participate in the study via email and were informed of the study background, methodology, and timeline. They were also informed of their roles and rights in the Delphi survey. The following statement preceded the survey questions for each questionnaire round to ensure that the participants consented voluntarily to participate in the study and were aware that their inputs and identity would be kept anonymous. The experts had to indicate their agreement before they could proceed to the questions.

"This survey is conducted as a part of the Delphi decisional process on classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activities by metabolic equivalents (METs), posture, and wakefulness status. You have been invited to participate as a panel member in the decisional process. Your participation in the survey is voluntary and your responses will be anonymous to the survey moderator and to other panel members. You are not required to respond to all questions, and you may quit with the survey at any time. However, to facilitate the decisional process, we would prefer if you would respond to all survey questions. Please also save your responses to open-ended questions in a Word file; just as a backup in case they are not recorded properly in the online survey. Do you consent to participate in this survey?"

<u>A communication process and Feedback from panel members</u>

3) Generating a questionnaire in an appropriate format for the target items

A questionnaire was developed to obtain feedback on the initial harmonisation and assessment of the ICATUS activities. The questionnaire consisted of open-ended questions asking the panellists to review assigned ICATUS activities and provide agreement or disagreement in each item. If they did not agree with the assessment, they were asked to provide suggestions or comments to improve the assessment. Using electronic technologies such as online questionnaires and email is another advantage for utilising the Delphi design.

Technology provides easy and fast access for both researchers and participants. It also increases capabilities of data processing, transmission and storage (Hsu & Sandford, 2007). The questionnaire was conducted by employing the leading online survey tool, Qualtrics. The questionnaire was electronically distributed to the panellists using anonymous link. The responses were recorded online with no identification of the originator and became available when completed for a summary report.

4) *Analysing the inputs and presenting a summation of results in the subsequent questionnaires*

The responses from the panellists were analysed qualitatively and used to construct the subsequent questionnaires. Therefore, at each round of the questionnaire, the panellists were asked to review items summarised by the survey facilitator based on the information provided in the previous round, except the first round that they began to review all assigned items. The harmonisation and assessment of the ICATUS activities were edited according to the suggestions and comments. Iterative questionnaires provide the Delphi panellists an opportunity to make further refinements or request more clarifications of the relative items (Hsu & Sandford, 2007). Besides the questionnaire, a summary report of each round was sent to the panellists to present responses to all comments reflected from the whole group so that they were well informed of the group feedback and reasons underlying modifications.

Theoretically, a series of questionnaire rounds can continue until an agreement from every member of the group is reached; however, three rounds of questionnaire are usually sufficient to develop consensus (Hsu & Sandford, 2007). The survey questions are available in the APPENDIX 4. The panellists of this study reached the consensus with the assessment of ICATUS activities at round three, except for three activities which received 75% agreement. The details of the assessment process can be found in the paper in Chapter VII.

Study 5: Trends and Correlates of Meeting 24-hour Movement Guidelines: a 15-year Study among 167,577 Thai Adults

Liangruenrom N, Dumuid D, Craike M, Biddle SJH, Pedisic Z. Trends and Correlates of Meeting 24-hour Movement Guidelines: a 15-year Study among 167,577 Thai Adults. Submitted to the International Journal of Behavioral Nutrition and Physical Activity. 2020.

This study was based on the Thai national time-use surveys conducted by the NSO using the ICATUS classification. Data of four ICATUS survey years in 2001, 2004, 2009, and 2015 were used for analysis. Cross-sectional analysis of four time-use survey years was undertaken among Thai adults aged between 18 and 59 years old. The total pooled sample is 167,577 (*n* = 37,702 in 2001; *n* = 37,544 in 2004; *n* = 45,751 in 2009; and *n* = 46,580 in 2015).

The time-use codes from the survey year 2001 was based on the Draft ICATUS comprising of 10 major groups of activities (National Statistical Office, 2002), including 1) employment for establishment; 2) primary production; 3) services for income and other production of goods; 4) household maintenance, management and shopping for own household; 5) care for children, the sick, elderly and disabled for own household; 6) community services and help to other households; 7) learning; 8) social and cultural activities; 9) mass media use; and 10) personal care and self-maintenance (Social and Housing Statistics Section, 1997). The other survey years (i.e., 2004, 2009, and 2015) used the Trial ICATUS consisting of 15 major groups of activities (National Statistical Office, 2005, 2011, 2016b), including 1) formal employment; 2) work for household in primary production; 3) work for household in non-primary production; 4) work for household in construction; 5) work for household services; 6) domestic services; 7) care-giving services; 8) community services; 9) learning; 10) socialising and community participation; 11) entertainment, cultural, and sports attendance; 12) hobbies, games, and other pastimes; 13) indoor/outdoor sports participation; 14) mass media; and 15) personal care and maintenance (Statistical Division United Nations, 2005).

Data Analysis

The Trial ICATUS is a revised version of the Draft ICATUS, and they are comparable (United Nations Statistics Division, 2017). Once all activities in the Draft ICATUS were matched with relative activities in the Trial ICATUS, they were categorised into sleep, SB, LPA, and MVPA based on the classification system of ICATUS developed in Study four. As mentioned in the Literature Review chapter, occupation and travelling time recorded in time-use surveys including the ICATUS do not provide sufficient information to assign MET values. To be able to do so, these activity groups need an additional linkage to more specific details. Therefore, prior to data analysis, occupational and travel-related activities were linked to respondents' occupations and mode of travel available in the household questionnaires. A summary MET value available from two previous studies was, then, applied (Deyaert, Harms, Weenas, Gershuny, & Glorieux, 2017; Tudor-Locke et al., 2009). For occupations, Deyaert et al. (2017) assigned METs to the list of International Standard Classification of Occupations 2008 (ISCO-08). In the Thai Time-Use questionnaires, occupations are classified using the previous version of ISCO-88. The ISCO-08 is an updated version of ISCO-88 with expanded index of occupation titles and codes (International Labour Office, 2012). However, these two classifications are comparable and there are correspondence tables of ISCO-08 to ISCO-88 available for public use (International Labour Office, 2012). Once occupation codes were harmonised, they were categorised into sleep, SB, LPA, and MVPA based on a summary MET estimate previously assigned (Deyaert et al., 2017). The list of ISCO-88 occupations classified into sleep, SB, LPA, and MVPA are summarised in the APPENDIX 5.

For travel-related activities, there is a 'where' variable in the Thai Time-Use questionnaires to indicate place (e.g., home, workplace, school) where a respondent was when performing corresponding activities. This variable was, then, linked and assigned MET values according to a summary MET estimate assigned to travel-related activities in Tudor-Locke et al. (2009).

When all activities from four survey years were assigned into sleep, SB, LPA, and MVPA, time spent in these behaviours were calculated and categorised into 'meeting' or 'not meeting' of the following recommendations (Khamput et al., 2017);

1) MVPA recommendation – to participate in at least 150 minutes/week of MPA, or 75 minutes/week of VPA, or an equivalent combination of the two PA intensities;
2) SB recommendation – to interrupt SB every 2 hours;
3) Sleep recommendation – to sleep between 7 and 9 hours per day;
4) MVPA recommendation for additional health benefits – to participate in at least 300 minutes/week of MPA, or 150 minutes/week of VPA, or an equivalent combination of the two PA intensities;
5) Meeting overall 24-hour guidelines – to meet MVPA, SB, and Sleep recommendations.

The rates of 'meeting' or 'not meeting' the abovementioned guidelines were measured on a daily basis. Time (in minutes) spent in MVPA, SB, sleep, and MVPA for additional health benefits were calculated to identify participants who met the five guidelines using the following criteria;

1) For meeting the MVPA recommendation – participants had more than 22 minutes of MVPA per day;
2) For meeting the SB recommendation – participants interrupted their SB every 120 minutes;
3) For meeting the sleep recommendation – participants slept at least 420 minutes and not more than or equal to 540 minutes per night;
4) For meeting the MVPA recommendation for additional health benefits – participants had more than 43 minutes per day;
5) For meeting overall 24-hour guidelines – participants who met MVPA, SB, and sleep.

This study using meta-regression to analyse 1) temporal trends of meeting 24-hour movement guidelines consisting of five recommendations abovementioned and 2) temporal trends in associations between sociodemographic variables (i.e., sex, age, region, household area, employment status, education level, marital status, and religion) and meeting these recommendations. We obtained regression coefficients from a series of meta-regression analyses which described how the percentages and odd ratios of meeting 24-hour guidelines changed across 15 years of survey periods. The statistical significance of the regression coefficients was tested to describe a linear or quadratic relationship. The *p*-value at <0.05 of each regression coefficient indicated whether this change was statistically significant. For odd ratio estimates, the log-transformation was conducted in the regression model to use the exponential of the regression coefficients as an estimate of the relative change. The details of the analysis can be found in the paper in Chapter VIII.

Ethics Approval

This PhD research used a combination of methods, including systematic reviews and secondary data analyses. No ethics clearance was needed for the two systematic reviews, as these studies included no data collection; they included only analysis and interpretation of previous findings. The remaining studies utilized existing datasets of the Thai national surveys; HWS and ICATUS; hence, they included no new data collection. These surveys received ethics approval from the NSO, and all participants gave informed consent. Permissions to access and use the data have been obtained from the NSO, and the conditions of use have been clearly stated that the data was used for the only purpose of research and never distributed to any third party without permission. The acknowledgement of the original data source was included in the respective papers and this thesis. For Delphi study, as part of the Delphi process, it is recommended that participants be informed of their roles and rights when participating in the Delphi survey as mentioned earlier. Therefore, prior to each survey iteration, participants were asked to provide written consent and agreement to voluntarily complete the questionnaire. They were also given the authorship to the study.

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CHAPTER IV: Physical Activity and Sedentary Behaviour Research in Thailand: A Systematic Scoping Review

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I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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Physical Activity and Sedentary Behaviour Research in Thailand: A Systematic Scoping Review

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Abstract

Background: The number of deaths per year attributed to non-communicable diseases is increasing in low- and middle-income countries, including Thailand. To facilitate the development of evidence-based public health programs and policies in Thailand, research on physical activity (PA) and sedentary behaviour (SB) is needed. The aims of this scoping review were to: (i) map all available evidence on PA and SB in Thailand; (ii) identify research gaps; and (iii) suggest directions for future research.

Methods: A systematic literature search was conducted through 10 bibliographic databases. Additional articles were identified through secondary searches of reference lists, websites of relevant Thai health organisations, Google, and Google Scholar. Studies written in Thai or

English were screened independently by two authors and included if they presented quantitative or qualitative data relevant to public health research on PA and/or SB.

Results: Out of 25,007 screened articles, a total of 564 studies were included in the review. Most studies included PA only (80%), 6.7% included SB only, and 13.3% included both PA and SB. The most common research focus was correlates (58.9%), followed by outcomes of PA/SB (22.2%), prevalence of PA/SB (12.4%), and instrument validation (3.2%). Most PA/SB research was cross-sectional (69.3%), while interventions (19.7%) and longitudinal studies (2.8%) were less represented. Most studies (94%) used self-reports of PA/SB, and few (2.5%) used device-based measures. Both sexes were examined in most studies (82.5%). Adults were the main target population group (51.1%), followed by older adults (26.9%), adolescents (15.7%), and children (6.3%). Clinical populations were investigated in the context of PA/SB in a relatively large number of studies (15.3%), most frequently those with cardiovascular disease, diabetes, and hypertension (22%, 21%, and 21% respectively).

Conclusions: The number of Thai papers on PA published per year has been increasing, indicating a growing interest in this research area. More studies using population-representative samples are needed, particularly among children and adolescents, and investigating SB as a health risk factor. To provide stronger evidence on determinants and outcomes of PA/SB, longitudinal studies using standardised measures of PA and SB are required.

Keywords: Physical activity, Sedentary behaviour, Scoping review, Thailand

Background

Deaths caused by non-communicable diseases (NCDs), such as cardiovascular disease and cancer, are common worldwide. Global rates of deaths attributed to NCDs increased from 60% in 2000 to 70% in 2015 [1]. Importantly, the rates of mortality caused by NCDs are increasing faster in low- and middle-income countries than in high-income countries [1]. In Thailand, NCD mortality rates increased from 64% in 2000 to 71% in 2015 [1]. Strong evidence has shown positive impacts of physical activity (PA) on the prevention of NCDs [2-5]. Some evidence also suggests that excessive sedentary behaviour (SB) (e.g. sitting) may increase the risk of several common NCDs, independently of PA [6]. It should be noted, however, that recent methodological papers questioned the independence of PA and SB, based on the argument that these behaviours are co-dependent parts of a time-use composition [7-9]. Nevertheless, the prevalence of physical inactivity, defined as not meeting the recommended level of moderate-to-vigorous physical activity (MVPA) and excessive SB, defined as sitting or reclining with low energy expenditure for more than 7 hours/day, is still high across the world, particularly in middle- and high-income countries [10-12]. In 2012, it was estimated that nearly three-quarters of all physical inactivity-related deaths occurred in low- and middle-income countries [13]. In Thailand, it was estimated that 6.3% of total mortality cases could be attributable to physical inactivity in 2013 [14]. Although, no country-specific estimates are available for Thailand, global estimates suggest that excessive SB is responsible for 3.4% of all-cause mortality [12].

Thailand has been affected by urbanisation, where, in search of better socioeconomic opportunities, many young working people move to urban areas or cities, especially to the capital, Bangkok. According to the Department of Economic and Social Affairs, United Nations, half of the Thai population (51.1%) is urban [13]. This increased rapidly from 1955 when only 18% of the Thai population lived in urban areas [13]. Many issues have arisen as a consequence of the increasing number of people living in the urban setting. An emerging concern related to urbanisation is the increasing time spent in SB in Thai population and its negative health outcomes [14]. In Thailand, there has been increasing focus on strategies to improve engagement in PA and reduce SB. Thailand has experienced significant economic development over the past four decades, moving from a low-income to upper-middle income economy [15]. Since 2002, Thailand has established a “Universal Health Coverage” scheme, to provide healthcare and financial protection to all Thai nationals [16].

As part of the national health promotion strategies, the Thai Government has aimed to promote engagement in PA since 1997 and has recently included targets to reduce SB as ways to reduce the burden of NCDs [17]. Moreover, a number of national actions have been taken to help achieve the World Health Organization’s (WHO) 15-year global target, set in 2010, of 10% reduction in the prevalence of physical inactivity, defined as less than 60 minutes of MVPA daily for adolescents and 150 minutes of MVPA weekly for persons aged 18 and over [17, 18]. WHO has commended Thailand as the regional leader in developing national health policies to promote better health through increasing PA [19]. Many PA promoting initiatives and public campaigns were introduced in Thailand, such as the development of new cycle paths, marathons organised all over the country, and a weekly program of aerobic exercise at workplace launched and led by the Prime Minister of Thailand [17, 19, 20]. Further, the national strategies and guidelines for increasing PA and reducing SB were developed [21]. Despite initiatives to increase the Thai population’s engagement in PA, population-based studies suggest that the prevalence of physical inactivity has increased from 18.5% in 2008 [22] to 19.2% in 2014 [23]. This suggests that the development and implementation of effective public health programs and policies to promote PA and decrease SB is needed.

In PA and SB epidemiology, a number of literature reviews have been conducted. For example, reviews have examined worldwide patterns of PA and SB, and show a shift from physically active to sedentary lifestyles [24-26]. Other reviews have examined factors associated with PA and SB, and the efficacy of interventions to influence the behaviours, especially in high-income countries [27-33]. However, most previous literature reviews are restricted to English language studies only and, therefore, studies from many low- and middle-income countries, including Thailand, have typically not been included. Furthermore, many previous reviews on PA and SB are restricted to specific, narrow topics (e.g. environmental determinants of PA) [27]. A comprehensive assessment of epidemiological evidence on PA and SB in the Thai context is lacking. To provide directions for future studies informing public health policies and actions targeted to increase PA and reduce SB, it is important to map the available evidence on epidemiology of PA and SB in Thailand. Scoping reviews have shown to be a useful method for a systematic assessment of the current body of evidence in a broad subject area [34]. In this study, we conducted a systematic scoping review to assess previous Thai PA and SB research, to identify research gaps and provide evidence-based directions for future research on PA and SB in Thailand to guide the development of strategies and policies.

Methods

Search strategy

This scoping review was conducted according to the Guidance for Conducting Systematic Scoping Reviews [35]. It included primary and secondary database searches. The primary literature search was conducted from database inception to September 2016 through the following bibliographic databases: Academic Search Premier; CINAHL; Health Source: Nursing/Academic Edition; MasterFILE Premier; PsycINFO; PubMed/MEDLINE; Scopus; SPORTDiscus; Web of Science (including Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Conference Proceedings Citation Index-Science, and Conference Proceedings Citation Index- Social Science & Humanities); and the Networked Digital Library of Theses and Dissertations (NDLTD). PubMed/MEDLINE, Scopus and Web of Science databases were searched using their own search engines, whilst other databases were searched through EBSCOhost. The search was conducted through titles, abstracts, and keywords of the indexed publications. The detailed search strategies, including the full search syntaxes, used for each database can be found in APPENDIX I.

Additional articles and grey literature documents were identified via secondary literature searching through: (i) the reference lists of all articles selected in the primary search; (ii) websites of ten relevant Thai public health institutions and organizations, including the Division of Physical Activity, Ministry of Public Health; Thai Health Promotion Foundation; Physical Activity Research Centre; Health Systems Research Institute; Thai NCD Network; Thai National Research Repository; Thai Thesis Database; and three university sources including Institute for Population and Social Research, Mahidol University; Chulalongkorn University Intellectual Repository; and Kasetsart University Research and (iii) Google and Google Scholar.

Study selection and inclusion criteria

All references from the primary database search were imported in EndNote X7 software (Thompson Reuters, San Francisco, CA, USA). After removing duplicates, the references were screened independently by two authors (NL and KS). The discrepancies between the study selections were resolved in discussion and consensus with a third author (ZP).

Studies were included in the present review, if they: (i) targeted any population group living in Thailand; (ii) conducted research on PA, physical inactivity, and/or SB; (iii) presented any quantitative or qualitative data relevant to public health, including but not limited to the levels, prevalence, correlates, determinants, or outcomes of engagement in PA and/or SB; or described the development or performed an evaluation of a PA and/or SB measurement tool or intervention; (iv) used any type of PA and/or SB measure, such as self-reports or device-based measures; (v) were written in Thai or English; and (vi) published as a journal article, conference paper, conference abstract, Master’s thesis, Doctoral thesis, or report. Studies were excluded, if they: targeted non-Thai populations; had the primary outcome(s) focusing on sports/exercise performance, or physical therapy; and were published as literature reviews, commentaries, and editorials.

Data extraction

The following data were extracted from the included studies: (i) general bibliographical information, including author names, publication year, title, publication type, full text availability, language of full text, abstract availability, and language of abstract; (ii) description of research methods, including study design, survey method, sample size, and sampling method; (iii) information about the study population, including sex, age, municipality (rural/urban), region, and other specific characteristics of participants; (iv) description of measures, including the type of PA/SB measure, device model or questionnaire name, domains included (such as work, transport, and leisure-time), information about whether the measure has been validated or not (if applicable), and intervention type (if applicable); and (v) information about the study objectives. The detailed data extraction table for studies used in the review is available in Additional file 2.

Results

Search results

The flow diagram depicting the search and study selection processes can be found in Figure 4.1. A total of 25,007 records were screened for inclusion. Of these, 8,389 studies were identified through primary searches, where, after removing duplicates, the titles and abstracts of 5,875 and full texts of 402 articles were screened. The secondary search yielded 16,618 results, of which 238 articles were selected. Overall, a total of 564 studies were included for review [36-598].

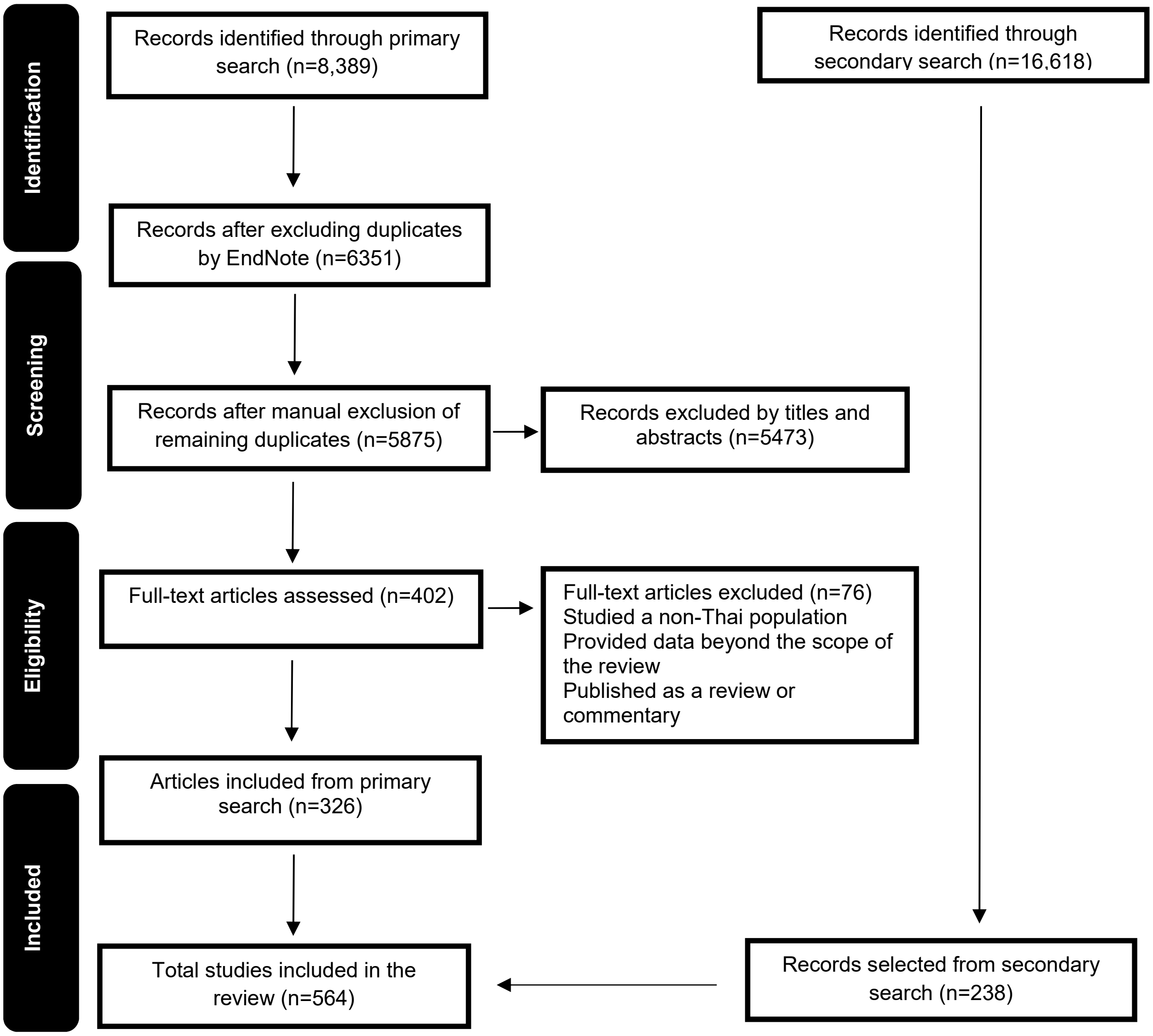

Figure 4. 1 Flow diagram of study selection process

Bibliographic characteristics of included studies

All papers included in this review were published between 1987 and 2016. The number of papers published per year has increased over time (Figure 4.2). English was the primary language used in the majority of Thai PA/SB papers full texts (67.4%), whilst nearly all papers (*n* = 546) had at least an English abstract (Figure 4.3). Furthermore, 17% of full-text articles and 10.1% of abstracts were not available online, and, therefore, other means were used to access the publications (e.g. authors' contacts and request through university libraries). Most studies were peer-reviewed journal articles (68.3%), followed by theses (19.9%), conference papers (6.6%), and reports (5.3%).

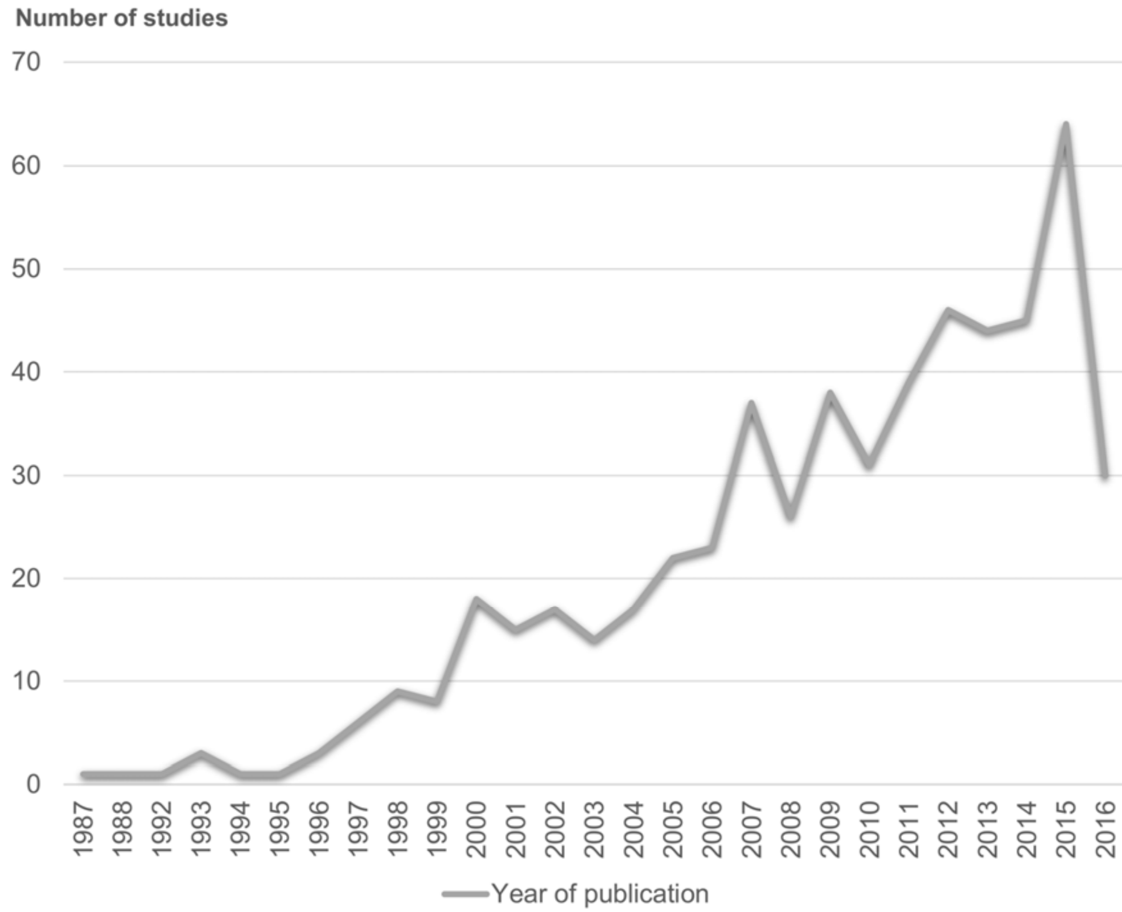

Figure 4. 2 The number of Thai studies on physical activity and sedentary behaviour published per year

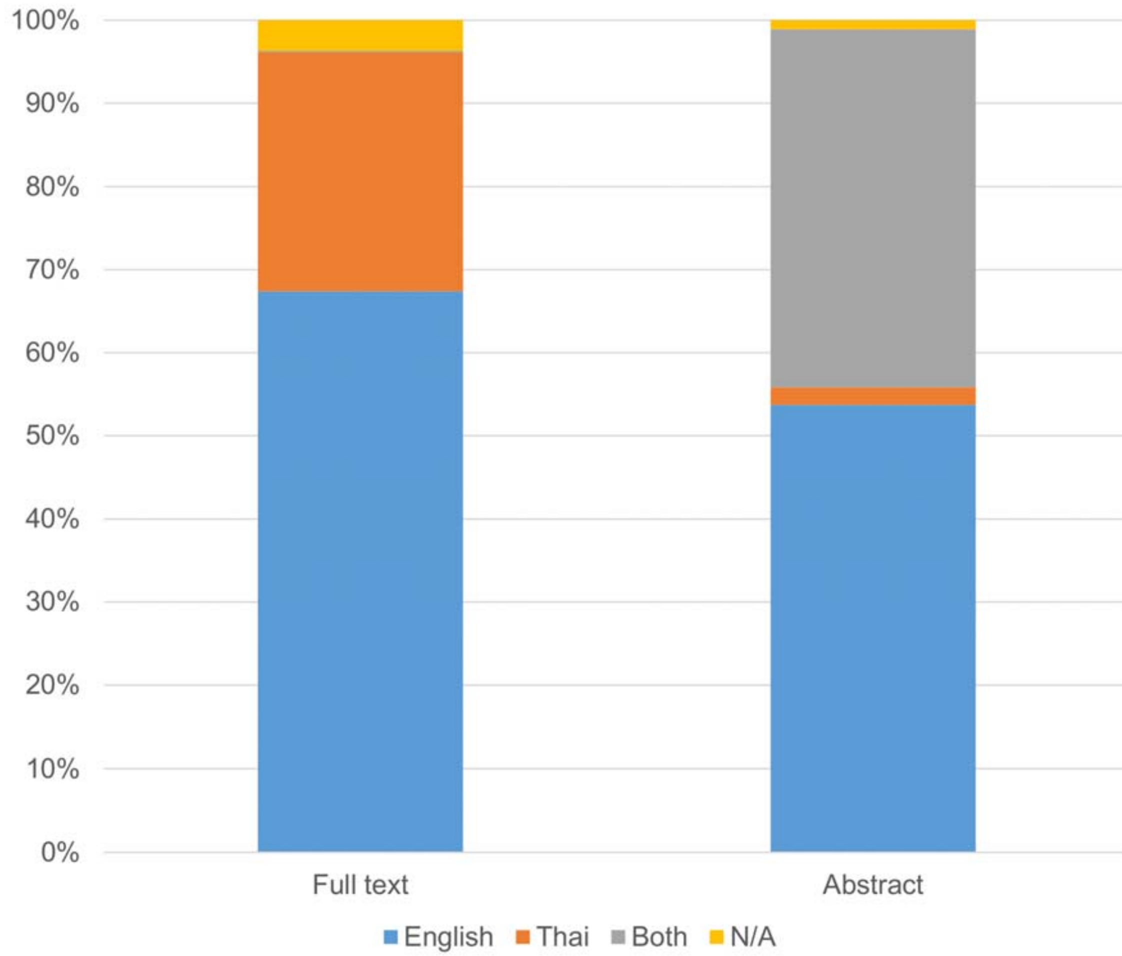

Figure 4. 3 Languages used in full-texts and abstracts of Thai physical activity and sedentary behaviour publications

Study characteristics

In 363 of 564 included studies (64.4%), PA and/or SB were the primary focus of the research (e.g. a study on correlates of PA), whilst the remaining studies were not strictly focused on PA and/or SB but were analysed among multiple other variables as key explanatory or outcome variables together with PA and/or SB (e.g. other lifestyle characteristics such as smoking). Eighty percent of the studies included PA only, 6.7% included SB only, and 13.3% included both PA and SB. Most studies focused on correlates of PA/SB (58.9%), followed by outcomes of PA/SB (22.2%), prevalence of PA/SB (12.4%), and instrument validation (3.2%). 69.3% of studies used cross-sectional designs. Less represented were intervention trials (19.7%), case-control studies (3.7%), longitudinal studies (2.8%), and measurement studies (2.3%). The majority of studies used quantitative methods (87.9%), with only 4.6% and 7.5% utilising qualitative methods or mixed-methods, respectively. In most studies, the data was collected using self-administered surveys (56.7%) or face-to-face interviews (31.4%) (Figure 4.4). The sample sizes of the studies ranged from 6 to 113,882 and 7.8% of the studies were conducted using nationally representative samples. Among the studies in nationally representative samples, 29.5% were secondary data analyses of the following national surveys: National Health Examination Survey; National Elderly Survey; Thailand Global School-Based Student Health Survey; 2007 National Physical Activity and Obesity Survey; and 2010 Evaluation of Health Promotion and Sports in Regions. There were seven government reports on PA and/or SB levels presenting results from population-based studies, such as the Health and Welfare Survey 2015 conducted by the National Statistical Office and National Health Examination Survey conducted by the National Health Examination Survey Office.

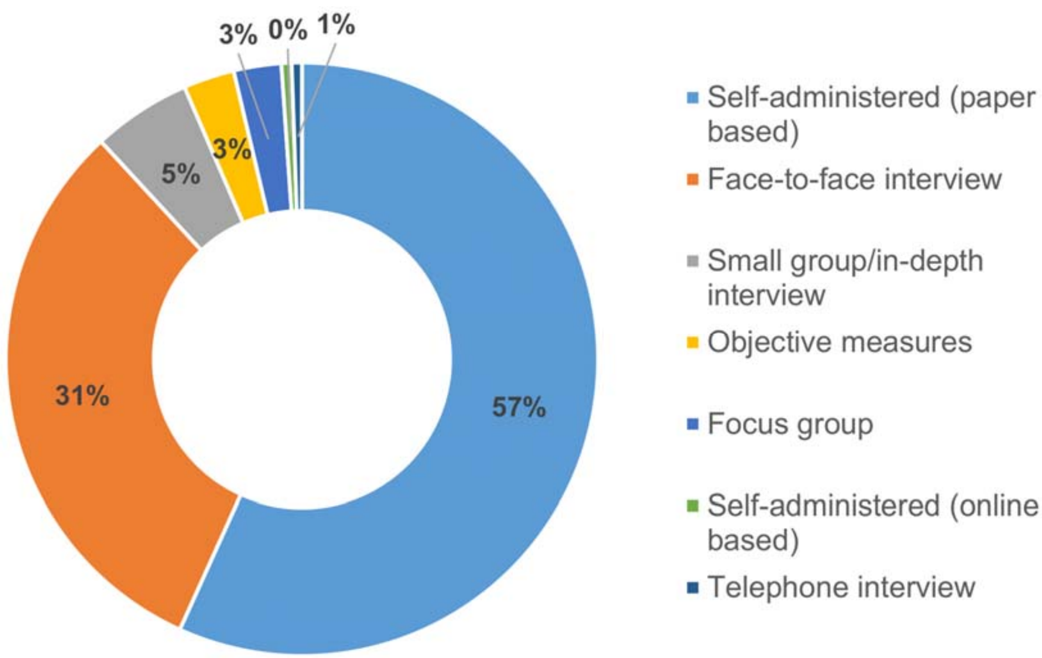

Figure 4. 4 Measures of physical activity and sedentary behaviour used in Thai studies

Characteristics of study samples

Participants of both sexes were included in 82.5% of studies. Studies of females only (15.4%) were more common than studies of males only (2.1%). Adults (18-59 years) were the most frequently investigated age group (51.1%), followed by older adults (60+ years; 26.9%), adolescents (10 to 17 years; 15.7%), children (4 to 9 years; 5.4%), and infants/toddlers (0 to 3 years; 0.9%). A large majority of studies were conducted in non-clinical populations (84.7%).

Of these, 28.5% were conducted among primary-school, secondary-school, high-school, and university students. Employees in health-related professions, including nurses, physicians, and health-care students such as medical residents were participants in 9.8% of studies. Other specific occupations were represented in 6.5% of studies; most common among them were farmers, military personnel, university staff, and office workers. Some studies (2.1%) were conducted among employees in specific organizations, such as the Electricity Generating Authority of Thailand, Metropolitan Waterworks, and the Teachers Council. Other specific non-clinical populations included in the studies were, for instance, people with low or high level of PA or SB regularity (5.6%), obese/overweight people (3.8%), women before or in menopause (2.9%), pregnant women (1.3%), and tobacco smokers (0.4%). Clinical populations were also examined in the context of PA/SB (17.7%). Patients with cardiovascular disease, diabetes, and hypertension were among the most frequently observed groups (22%, 21%, and 21%, respectively). Hip/knee problems (13%) and cancers (6%) were also clinical conditions of interest (Table 4.1). By geographical distribution, Bangkok the capital was the most studied area (28.8%) and the Southern region was the least studied area (15.2%).

Table 4. 1 Population groups studied in Thai physical activity and sedentary behaviour research

Population groups	**No. of studies**
Non-clinical populations	
Students	136
General (no specific characteristics)	135
Occupation-specific populations	31
Groups based on PA/SB participation	27
Health-care students	27
Health-care professionals	20
Obese/overweight	18
Pre/post-menopausal women	14
Employees of a specific organization	10
Multiple populations groups	10
Pregnant and postpartum women	6
Ageing population	5
Religious groups	4
Smokers/non-smokers/ex-smokers	2
Others	19
Total	**464**
Clinical populations (general characteristic)	

Population groups		No. of studies
Cardiovascular disease		22
Diabetes		21
Hypertension		21
Hip/knee injury/condition		13
Cancer		6
Respiratory disease/condition		4
Parkinson’s disease		3
Diabetes and hypertension		2
Epilepsy		2
Dementia		1
	Total	**100**

Measures of physical activity and sedentary behaviour

Out of 526 studies that investigated PA, most relied on self-reports only (73.4%) and 2.1% used both self-report and device-based measures. In nearly all of these studies (97.2%) PA was assessed using self-reported or proxy-reported questionnaires, and in most cases, it was not specified which questionnaire or questionnaire item(s) were used for this purpose. The Global Physical Activity Questionnaire (GPAQ) and the International Physical Activity Questionnaire (IPAQ) were used in 25 (6.5%) and 23 studies (6%), respectively. Other self-reports were PA diary and logbook used in 14 studies (3.5%). Device-based measurement was used in 23 studies (4.4%), with accelerometer (n = 10) and pedometer (n = 9) being the most common devices. A large proportion of PA studies focused on exercise only (49.6%) or on total PA (32.5%). Domain-specific PA levels, including leisure-time, household, work-related, and transport PA, were examined in isolation in 2.5% of all PA studies. The most commonly studied domain of PA was leisure time (n = 16). Walking, as a type-specific PA, was investigated independently in 5 studies. In total, 5.9% of studies assessed a combination of domain- and type-specific PA levels, including exercise, sport and walking.

A total of 113 studies examined SB. Questionnaires were the most common measure of SB (91.2%), followed by activity diaries (4.4%), and device-based tools (3.5%). Most studies (65.5%) did not specify which questionnaires they used. GPAQ, IPAQ, and accelerometers were used in eight, four, and two studies, respectively. Screen time - including TV viewing, computer use, videogames, and internet/social networking - was the most commonly investigated type-specific SB (59.3%). Total sedentary or sitting time was assessed in 37 studies (32.7%), while SB in work and leisure-time domains was assessed in seven and five studies respectively.

Study topics

Correlates of PA and/or SB were the most common topic and were investigated in 58.9% of studies. We identified 11 groups of PA/SB correlates. The most common were: socio-demographic correlates, such as, age, gender, and education level (24%); psychological correlates, such as mental health and well-being, self-efficacy, social behaviours, and cognitive tasks (20.9%); physical health and functioning correlates including physiological and biological functions, diseases, and health problems (19.8%); and social and cultural correlates, such as social support, beliefs, and social practices (11.4%). Other reported correlates included: health behaviours and lifestyles; physical environment; general health; physical skills, abilities, and fitness; academic performance; knowledge; and policy (Table 4.2).

In total, 125 (22.2%) of the selected studies examined outcomes of PA and/or SB. Most of these studies examined physical health and functioning (33.8%), psychological outcomes (21.8%), physical skills, abilities, and fitness (19.4%), and health behaviours and lifestyles (14.8%). Other reported outcomes included general health; mortality; social characteristics; environmental characteristics; and knowledge (Table 4.2).

Table 4. 2 Number of studies investigating correlates and outcomes of physical activity and sedentary behaviour in Thai populations

Categories	Correlates		Outcomes	
	No. of studies	%	No. of studies	%
Socio-demographic	162	24	-	-
General health	37	5.5	9	4.2
Physical health and functioning	134	19.8	73	33.8
Physical skills, abilities, and fitness	10	1.5	42	19.4
Psychological	141	20.9	47	21.8
Health behaviours and lifestyle	35	5.2	32	14.8
Social and culture	77	11.4	2	0.9
Physical environment	38	5.6	1	0.5
Academic/school performance	8	1.2	-	-
Mortality	-	-	2	0.9
Knowledge	27	4.0	8	3.7
Policy	6	0.9	-	-
Total*	**675**	**100**	**216**	**100**

Note: *Multiple correlates and/or outcomes were investigated in some studies; hence the sum of the totals is greater than the total number of included studies.

A number of measures were tested for validity and reliability in the Thai context (6.7%). These were mostly questionnaires (92.1%) such as GPAQ, IPAQ (short version), Godin-Shephard Leisure-Time Physical Activity Questionnaire (GSLTPAQ), Modifiable Activity Questionnaire for Adolescents (MAQA), and Perceived Benefits to Physical Activity Scale (PBEPAS). Two studies evaluated measurement properties of device-based measures of PA (pedometer and heart rate monitors). In one study [159] the Compendium of Physical Activities [599] was translated and validated.

Discussion

This study is the first systematic scoping review that summarises current evidence of Thai PA and SB research to support national directions in promoting healthy lifestyle through PA. We identified a large number of PA and SB studies conducted in Thailand, covering a broad range of topics, and using a variety of study designs. There was an increase in the number of Thai PA and SB studies published per year, from one study in 1987 to 64 studies in 2015 (the search was conducted up to September 2016), indicating a growing interest in this research area.

The first Thai publication focusing on PA that we identified was a doctoral thesis from 1987 [289], however the vast majority of PA studies were published in the last two decades. Importantly, the number of Thai papers on PA published per year has been increasing (Figure 4.2), indicating that this area of research is developing. It is important to note that half of the studies on PA focused on exercise only, overlooking other types of PA (such as occupational PA, household PA, transport-related PA, and leisure-time PA other than exercise). Historically, the terms ‘physical activity’ and ‘exercise’ have been used interchangeably, and exercise has been one of the most commonly studied types of PA [600]. However, exercise is only one out of several various specific types of PA that may be important for health. From the public health perspective, it is important to study not only exercise but also other types of PA. In Thailand, the term “exercise” had been more widely used until the “physical activity” term was formally promoted in 2002, when the national focal point was changed from the Exercise Unit to the Division of Physical Activity and Health [17].

This finding for Thai studies is consistent with global trends in PA research over the last few decades. The proportion of studies using total MVPA (and not just exercise) as a measure of PA has increased in the last decade [49, 67, 230, 231, 432]. To align with Thai national recommendations on total MVPA, this trend in gathering evidence should be continued in future studies. Importantly, we did not locate any Thai population-based study that considered participation in muscle-strengthening activities, which is similar to the situation in most other countries [601, 602]. Given that Thai national PA guidelines for adults include a separate recommendation on participation in muscle-strengthening activities [603], this suggests more studies on this specific type of PA are needed.

Up until the present, studies on SB in Thailand were less represented than those on PA. SB research is a more recent field of inquiry, compared with PA epidemiology. It has only been in the past two decades that SB has been recognised as a risk factor independent of PA level [604-607]. It was therefore expected that in Thailand SB research would be less developed than PA research. Of the 113 studies addressing SB, 40 looked at specific types of SB, such as TV viewing, computer/internet use, and playing video games. The earliest Thai study we identified that examined type-specific SB, was conducted in 1994, as part of a doctoral thesis focusing on TV viewing and academic achievement [99]. The first study assessing total SB was conducted in 2000, again as part of a doctoral thesis [434]. Since then, there has been a steady increase in the number of Thai papers on SB published per year, indicating an increasing recognition of the importance of this area of research. Given the prevalence of SB and its potential negative health outcomes [6, 12], it is important that future studies continue to focus on SB in Thai populations.

Recent methodological developments have led to the establishment of a new discipline, called time-use epidemiology, where periods of time spent in PA, SB and sleep are no longer considered as independent risk factors, but instead are treated as mutually exclusive and exhaustive parts of the 24-hour day [7-9]. The new approach allows for drawing conclusions about how different reallocations of time between PA, SB and sleep affect health, and for finding the optimal balance of these components of time-use for good health [9, 608]. In line with the new developments and with the public health guidelines adopted in other countries [609-611], the most recent Thai guidelines on movement/non-movement behaviours included recommendations on PA, SB, and sleep [603]. However, the current review found no Thai studies aligned with this new approach, suggesting that this might be an area worth exploring in future epidemiological studies in Thailand.

Almost 70% of all included studies (PA and SB) used cross-sectional designs, whilst the evidence base on determinants and outcomes of PA/SB from longitudinal studies and intervention trials is less developed, potentially due to affordability-related reasons. However, a limitation of cross-sectional data is that they do not allow to draw conclusions about the direction of analysed relationships. To get a better insight into potential causes and consequences of PA and SB, longitudinal studies and controlled intervention trials are needed.

Most studies in Thailand assessed PA and/or SB using self-reports. Despite the limitations of self-report instruments [612], these are still the predominant measure of PA and SB in population-based surveys internationally [613, 614]. The use of device-based measures of PA and SB, such as accelerometers, in large-scale epidemiological studies is becoming more affordable, especially in high-income countries [615-617]. However, device-based measurement of PA and/or SB was seldom used in the Thai context. This is likely due to issues related to the high cost and participant burden associated with device-based measurement of PA and SB [614]. Although device-based measuring has limitations in assessing domain- and type-specific PA and SB levels, it may provide some data that cannot be reliably assessed by existing questionnaires (e.g. timing of different activities during a day, detailed data on weekly distribution of PA). To better understand patterns of PA and SB in Thai populations, future research might benefit from employing device-based measures alongside self-report measures.

Although studies included in this review used a variety of sampling methods and a broad range of sample sizes, few were conducted in large-scale population-representative samples. Besides national surveys funded by the Thai government using large scale data samples, such as National Health Examination Survey, Thailand Physical Activity Children Survey, National Physical Activity and Obesity Survey, and Health and Welfare Survey, 10 other studies also utilized a large-scale sample (*n* range: 24,743 – 87,143) from the Sukhothai Thammathirat Open University cohort. To improve the generalisability of findings from observational studies, the use of such large, nationally representative samples should be encouraged in future Thai PA and SB research.

Across age categories, young to middle aged adults (18-59 years) were the most commonly studied population group, followed by older adults (60+ years). The convenience of conducting research among adults and older adults, compared with research among children and adolescents, in terms of ethical considerations, ease of access to participants, and simplicity of measurement, may partially explain why most Thai PA and SB studies focused on these age groups. Another reason may be that adulthood and older age are more convenient stages to observe health impacts of PA and SB, as symptoms of many diseases rarely occur in younger population groups [618]. However, in addition to a number of topics in PA and SB research that are specific for children and adolescent populations (e.g. levels and patterns of school-based PA and SB, tracking of PA and SB from childhood to adolescence, association of PA and SB with educational outcomes in primary and secondary schools, effectiveness of PA and SB interventions in the school setting), findings among adults may not be generalizable to the populations of children and adolescents, which calls for more studies of these age groups in the future.

Thai PA and SB studies covered a wide range of topics, largely consistent with PA/SB research trends in middle- and high-income countries globally [5, 10, 12, 27]. However, there has been limited research on environmental correlates/determinants of PA and SB, associations between PA/SB and mortality outcomes, PA/SB policy research, and validation of device-based measures of PA/SB in different Thai population groups (e.g. across different sociodemographic groups). Around one-third of Thai PA/SB papers were published in the Thai language, while the remaining papers were published in English. Publications in English have higher visibility in the international scholarly context. Alternatively, publications in Thai may better inform local public health stakeholders, media and the general non-academic readership. Ideally, all publications would be in both languages, but in reality, this is not feasible. It is, therefore, important to keep a balance between publishing in Thai and English, by always carefully considering the primary purpose of the paper and the targeted readership.

This systematic scoping review has several strengths. First, a systematic search and study selection strategy were applied to identify eligible studies. Comprehensiveness of the search was achieved by using a large number of relevant PA- and SB-related keywords, conducting primary search through 10 bibliographic databases, and supplementing this with an extensive secondary search. Second, data on 39 variables were extracted from the selected studies, which allowed for a detailed interpretation of the current situation in Thai PA and SB research. Last, a key strength was that, since both Thai and English language papers were included, we were able to review a large number of studies that might not have been captured if we only reviewed papers in one language.

This scoping review has some limitations. Although we tried to identify as many studies as possible, we may have missed some studies because they were not indexed in the selected databases. Furthermore, given the large total number of included studies, we focused on providing general recommendations, whilst an in-depth assessment of each individual study was not feasible. Future reviews are needed to summarise findings on specific topics in PA/SB epidemiology within the Thai context, particularly by different age groups (e.g. children, adolescents, adults, and older adults.

Summary recommendations for future research

Based on this systematic scoping review, it can be concluded that the greatest Thai PA/SB research gaps and limitations are: the lack of studies on SB; the use of unspecified and non-validated measures of PA and SB; a limited number of longitudinal studies; a limited number of studies conducted in population-representative samples; a limited number of studies conducted among children and adolescents; a limited coverage of several important PA/SB research topics, such as environmental factors. To provide stronger evidence and further improve the evidence base on PA and SB, future studies may consider several recommendations stemming from this review. First, given that SB research is less developed in the Thai context and that SB is emerging as a new and important health-risk factor among the Thai population [16], more studies on determinants of, outcomes of, and ways to reduce SB in the Thai population are needed. Future studies in Thailand would also be strengthened by using validated device-based and self-report measures of PA and SB. For a better understanding of determinants and outcomes of PA and SB in Thailand, future studies should aim to use longitudinal study designs. Additionally, to allow for better generalisation, more studies should use large, population-representative samples. Besides, future studies are needed specifically focusing on topics relevant to children and adolescents. Finally, research shows that PA is influenced by a number of individual, social, environmental, and policy factors [27, 619]. Whilst socio-demographic, psychological, and social correlates have been the topic of a number of Thai studies, more research is needed on environmental and policy-related correlates of PA and SB in Thailand.

Conclusions

Thai research on PA and SB has rapidly evolved and received increasing attention in the last two decades. Substantial literature was mapped in this review, showing that existing research has a great potential to support the development of healthy lifestyles by increasing PA and reducing SB in Thailand. However, current evidence could be strengthened, particularly by conducting more research on SB, using sound research methods, and covering the full range of research topics on determinants and outcomes of PA and SB. By following the recommendations provided in this systematic scoping review, future studies may provide even stronger evidence needed to inform public health efforts to promote PA and reduce SB in Thailand.

List of abbreviations

- Physical Activity (PA)
- Sedentary Behaviour (SB)
- Moderate-to-Vigorous Physical Activity (MVPA)
- Global Physical Activity Questionnaire (GPAQ)

- International Physical Activity Questionnaire (IPAQ)
- Non-Communicable Diseases (NCDs)
- World Health Organization (WHO)
- Godin-Shephard Leisure-Time Physical Activity Questionnaire (GSLTPAQ)
- Modifiable Activity Questionnaire for Adolescents (MAQA)
- Perceived Benefits to Physical Activity Scale (PBEPAS)
- Networked Digital Library of Theses and Dissertations (NDLTD)

Additional files

Additional file 1

> **File name:** Additional file 1-search strategies.pdf
>
> **Title:** Search keywords
>
> **Description:** Detailed search keywords including the full search syntaxes used for each database

Additional file 2

> **File name:** Additional file 2-data extraction.xlsx
>
> **Title:** Data extraction table
>
> **Description:** The detailed table of all data extracted from each study included in this review

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Availability of data and materials

The summary of reviewed articles is available in Tables, Figures, and Supplementary materials.

Authors' contributions

NL and ZP conceived the idea for the review. NL, ZP, SJHB and JAB conceptualised the review. NL took the lead in writing the study protocol. NL and ZP designed the systematic search strategies. NL and KS conducted the study selection. NL did the data extraction and analysed the data. NL drafted the initial manuscript. ZP, JAB, MC, SJHB, and KS contributed to writing the manuscript. All authors read and approved the final draft.

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Competing interests

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The other authors declare no competing interests.

Consent for publication

Not applicable

Ethics approval and consent to participate

Not applicable

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CHAPTER V: Do Thai People Meet Recommended Physical Activity Level?: the 2015 National Health and Welfare Survey

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GRADUATE RESEARCH CENTRE

DECLARATION OF CO-AUTHORSHIP AND CO-CONTRIBUTION: PAPERS INCORPORATED IN THESIS BY PUBLICATION

This declaration is to be completed for each conjointly authored publication and placed at the beginning of the thesis chapter in which the publication appears.

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2. CANDIDATE DECLARATION

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

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2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. There are no other authors of the publication according to these criteria;
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Do Thai People Meet Recommended Physical Activity Level?: the 2015 National Health and Welfare Survey

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Abstract

This study aimed to determine the adequacy of physical activity levels of Thai adults overall, and disaggregated by subgroups of participants. The study re-analysed data of 108,416 Thai adults aged 18 and above from the 2015 National Health and Welfare Survey conducted by National Statistical Office. Descriptive and analytical statistics were used to analyse the data. The results showed that 42.4% of Thai adults aged 18 and above met recommended physical activity levels of the World Health Organization and 33.8% had high levels of physical inactivity. Most males, farmers and labourers, and those who had no underlying diseases, reached recommended physical activity levels and had low sedentary behaviour. On the other hand, most elderly, unemployed, and those who had underlying diseases, did not reach recommended physical activity levels and had high sedentary behaviour. Our findings will contribute to national policy development to increase physical activity and reduce sedentary behaviour especially in work and transportation domains, with the focus on the sub-populations that did not reach recommended physical activity levels and had high sedentary behaviour.

Keywords: Physical activity, Physical inactivity, Sedentary behaviour, Health and welfare survey, Thailand

Background

Physical inactivity is one of the risk factors for non-communicable diseases (NCDs). The World Health Organization (WHO) estimated that approximately 3.2 million of deaths worldwide were caused by physical inactivity [1-3]. In Thailand, around 11 thousand people died due to physical inactivity in 2009 [4]. Physical activity (PA) is undertaken in different contexts and WHO categorises PA according to three domains—occupation, transportation, and recreation. Sedentary behaviour (SB) is considered as another domain of activity involving low energy expenditure during waking hours in a sitting or reclining posture such as TV viewing, reading, and driving [3, 5]. The intensity within each of these domains is measured in metabolic units (Metabolic Equivalent of Tasks: METs). According to WHO, resting energy expenditure or sitting quietly is assumed to be 1 MET [3]. Activities of 4 or more METs are generally defined as moderate (e.g. walking, cycling), and activities of 8 or more METs are considered as vigorous (e.g. running, playing basketball) [3, 5]. The WHO recommends adults aged 18 and over conduct PA at least 600 metabolic equivalent minutes (MET-minutes) per week or a minimum of 150 minutes per week of moderate-intensity PA or 75 minutes per week of vigorous-intensity PA or equivalent combination of activities from both intensities [3].

The WHO developed the monitoring tool ‘Global Physical Activity Questionnaire’ (GPAQ) to measure and monitor PA levels in the population [5]. PA level has been estimated in many countries using GPAQ. It was shown that 66% of people worldwide had enough PA according to WHO recommendations [3]. In Thailand, the prevalence of PA sufficiency is declining. In 2003, around 78% of the population had sufficient PA [6], 85% in 2007 [7], 82% in 2008 [8], 66% in 2012 [9], and 68% in 2013 [10] and 2014 [11]. Consequently, physical inactivity has become an important health issue at a global level. The Member States of the United Nations adopted the political declaration at the high-level meeting of the General Assembly on the prevention and control of NCDs. Accordingly, Governments agreed to implement the NCD Global Action Plan through the attainment of a set of nine voluntary global targets. One of the targets was a 10% reduction of physical inactivity by 2025. To achieve this target, Thailand has to reach at least 84% in prevalence of sufficient PA within the mentioned timeframe [12]. However, when considering the sufficient PA level of Thai people from past surveys, the results are inconsistent. This may be caused by many factors such as different organizations who conducted a survey, and different surveys which used different tools and methodology. To provide a consistent population-based PA information, the National Statistical Office (NSO), which conducted a national survey on exercise participation in the Thai population aged 11 and older in 2003, integrated GPAQ into its national Health and Welfare survey. The PA information of the largest sample size of around 140,000 Thai residents is now available.

The aim of this study, therefore, was to determine the prevalence of sufficient PA in the Thai population aged 18 and over from the national representative survey. We also aimed to facilitate the development of PA promotion policies, monitor and report the progress of physical inactivity reduction target from PA promotion campaigns in Thailand.

Methods

Data source

This study was based on secondary data analysis of the 2015 Thai National Health and Welfare Survey (HWS), conducted by the NSO between March and April 2014. The author team obtained permission to access the dataset from the NSO.

Participants and data collection procedure

The stratified two-stage sampling method was used to randomly recruit sample households from urban and rural areas in every province of Thailand. The primary sampling units were communities for an urban area and villages for a rural region. A total of 1,990 communities and villages were selected from the first-stage sampling. The secondary sampling units were households and a total of 27,960 individual households were randomly selected. A total of 139,848 participants living in these private households were interviewed face-to-face. The unweighted data were extrapolated to approximately 67 million of the Thai population.

Sociodemographic variables

Sociodemographic information on sex, age, urban/rural area, region, education level, occupation, and income quintiles were elicited from participants. Participant age was grouped into three categories; 18 – 34 years, 35 – 50 years, and 51 years or older. Region was classified as Bangkok Metropolis, Central (excluding Bangkok), North, Northeast, and South. Highest education level was categorised into three groups; none or primary school, secondary or high school, and college or higher. Occupation was clustered into seven groups; unemployed, executives, clerks, service and commercial workers, workers in agriculture/fishery, workers in factory and production, and labourers and other basic jobs. Participant household income was classified into five quintiles, the first quintile (Q1) being the 20% poorest, while the last quintile (Q5) being the 20% richest.

Health variables

Health status was acquired from two characteristics; namely, having underlying disease and self-rated health problems. Underlying disease was reported as yes or no. Health problems were self-assessed in five aspects; movement, self-care, routine activities, illness, and depression. The intensity of the problems was rated into five levels; none, low, moderate, high, and extremely high or unable to perform related tasks.

Measures of physical activity and sedentary behaviour

Information on PA and SB were collected using GPAQ, the questionnaire developed by the WHO as a tool to NCD risk factor surveillance. The GPAQ includes questions about weekly frequency and usual duration of; vigorous-intensity and moderate-intensity PA in the domain of work; cycling and walking in the transport domain; and vigorous-intensity and moderate-intensity recreational activities. The questionnaire also includes a single item on total time spent sitting or reclining on a typical day or SB.

Data processing and statistical analysis

We analysed the data using STATA version 13.0 (StataCorp, Texas, USA). The sociodemographic data were statistically weighted and presented in percentage and means separately for sex, age, urban/rural place of residence, region, education level, occupation, and income quintiles. Sufficient PA was determined according to the WHO guideline on moderate and vigorous PA for health of meeting at least 600 MET-minutes/week [3].

Assessment of physical activity and sedentary behaviour

We computed the sum of the total MET-minutes/week of activities from all PA settings (occupation, transport, and recreation) as follows: intensity of the activities (MET) x duration (minutes) x number of days per week. The total PA MET-minutes/week was divided by 600 (PA cut-off value) to present 'respondent sufficiency of PA level'. For example, if one respondent reported <u>in a work domain;</u> vigorous PA – 0 day/week, moderate PA – 2 days/week and 10 minutes each day, <u>in a transport domain;</u> moderate PA – 5 days/week and 30 minutes each day, and <u>in a recreation domain;</u> vigorous PA – 3 days/week and 20 minutes a day, and moderate PA – 3 days/week and 30 minutes a day. The equation for sufficient PA was: [(8 MET x 0 day/week x 0 minute) + (4 MET x 2 days/week x 10 minutes) + (4 MET x 5 days/week x 30 minutes) + (8 MET x 3 days/week x 20 minutes) + (4 MET x 3 days/week x 30 minutes)] / 600 = 2.53

Therefore, this respondent had adequate PA. However, since it was possible that the participants may report unrealistic values of time spent in activities, we set minimum and maximum realistic values of moderate and vigorous PA in each domain including SB. The minimum value was set at 0 minute per day for both PA and SB values. The maximum hours of PA were limited as follows.

- Moderate to vigorous PA in work domain ≤ 12 hours/day [13]
- Moderate PA in transportation ≤ 6 hours/day [13]
- Moderate to vigorous PA in leisure time ≤ 6 hours/day [13]
- SB ≥ 17 hours/day [14]

Outcomes of physical activity

We determined the associations between the sociodemographic and health status variables with sufficient PA using logistic regression analysis. We used 'enter method' to select independent variables that were statistically significant in the analysis [36].

Outcomes of sedentary behaviour

According to the WHO the term 'physical inactivity' is used to refer to those who do not meet the PA recommendations of 150 minutes of moderate-intensity PA, or 75 minutes of vigorous-intensity PA, or an equivalent combination of moderate- and vigorous-intensity PA of at least 600 MET-minutes/week [3, 5]. SB is defined as activities with expended energy equivalent of 1 MET such as sitting quietly [3, 5]. Therefore, our variable 'high SB' was created to refer to those who had no moderate (4 MET) and/or vigorous (8 MET) PA in all domains (occupation, transportation, and recreation) and reported SB (1 MET). We presented SB outcomes in association with sociodemographic and health status variables using logistic regression analysis. We applied 'enter method' to select significant independent variables in the analysis [36].

Results

Demographic characteristics

A total of 108,416 participants were included in the study and statistically weighted to represent the total Thai population aged 18 years and over; equivalent to 52,382,909 Thai people. There was a slightly higher proportion of female participants (51.8%) than males. When stratified by sex, participants living in urban and rural areas were equally distributed.

The majority of the study participants (50.4%) did not graduate or finish primary school. Table 5.1 shows sociodemographic characteristics of the study participants.

Table 5. 1 Sociodemographic characteristics

Variable	Total	Female	Male
n (%)	52,382,909	51.8	48.2
Household area (%)			
Non-municipal area	54.3	53.9	54.7
Municipal area	45.7	46.1	45.3
Regions (%)			
Bangkok	13.9	14.0	13.8
Central	29.6	29.4	29.7
North	17.2	17.2	17.1
Northeast	26.4	26.6	26.3
South	12.9	12.8	13.1
Age groups (%)			
18-34 years	31.5	30.4	32.8
35-50 years	33.5	33.2	33.8
51 years and over	35.0	36.4	33.4
Highest education levels (%)			
None or primary school	50.4	52.6	48.0
Secondary or high School	31.6	28.8	34.6
College or higher	18.0	18.6	17.4
Occupation (%)			
Unemployed	26.2	33.6	18.2
Executives	8.6	8.1	9.1
Clerks	3.3	4.5	1.9
Service and commercial workers	14.3	16.0	12.5

Variable	Total	Female	Male
Workers in agriculture/fishery	24.9	21.8	28.2
Workers in factory and production	15.0	8.2	22.4
Labourers and other basic jobs	7.7	7.7	7.7
Asset of Quintiles (%)			
Lowest quintile (Q1)	21.1	23.4	19.7
Second quintile (Q2)	19.1	20.3	18.5
Third quintile (Q3)	22.1	21.1	22.7
Fourth quintile (Q4)	17.5	16.3	18.2
Highest quintile (Q5)	20.2	18.9	20.9

Prevalence of sufficient physical activity and sedentary behaviour by sociodemographic characteristics

The percentage of the Thai population aged 18 and over who had sufficient PA was 42.4%. When analysed by sociodemographic characteristics, we found that the percentage of males who had sufficient PA (49.2%) was higher than females (36.2%). The participants aged 51 and over and unemployed had high SB, 33.8% and 28.8% respectively. Conversely, labourers and workers in agriculture/fishery were the two groups with highest sufficient PA (56.5% and 54% respectively). For SB, 33.8% of the Thai population aged 18 and over reported high SB. The population groups with high level of SB were females (37.4%), older age 51 and over (43.6%), no education or primary school (37.1%), and unemployed (46.1%). (See Figure 5.1)

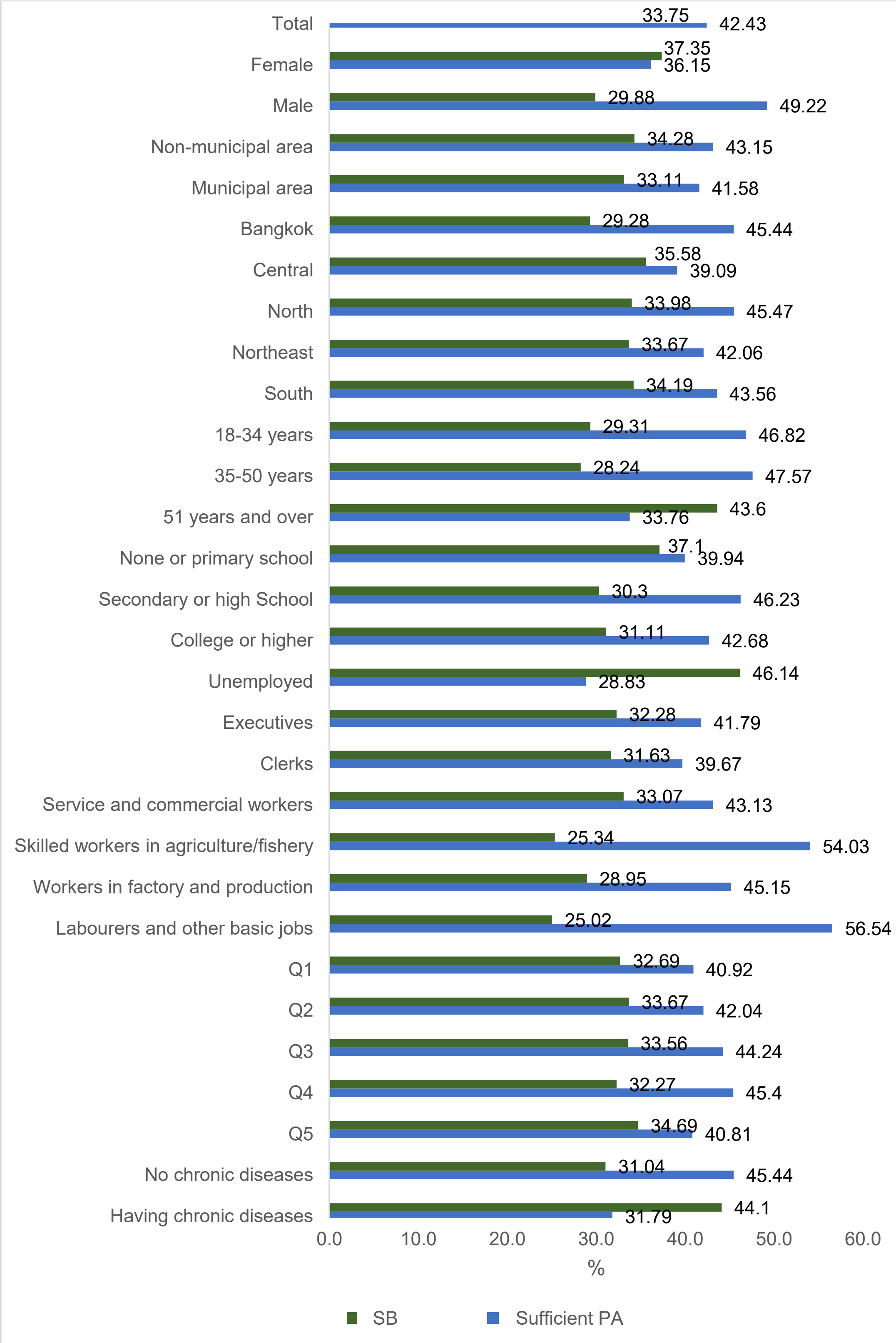

Figure 5. 1 Sufficient physical activity and sedentary behaviour by sociodemographic characteristics

Prevalence of sufficient physical activity and sedentary behaviour by health status

The percentage of Thai people who reported no underlying diseases had higher levels of sufficient PA (45.4%) than those with underlying diseases (31.8%). Higher levels of each of the five aspects of health status; movement, self-care, routine activities, illness, and depression was associated with. It was found that the higher level of health problems in all aspects lowered levels of PA participation. For example, participants who rated high on their movement problems had the lowest level of sufficient PA (15.2%), while those who rated movement problems lower had higher sufficient PA level (none, low, moderate, high, and extremely high or unable to perform the related health tasks; 15.6%, 28.1%, 29.5%, and 44.9% respectively). On the other hand, participants with underlying diseases had higher SB (44.1%), than those who did not have chronic diseases (31%). When categorised into five aspects of health problems, it was found that the higher of the problems, the higher the level of SB. For example, participants who reported having the highest level of problem on routine activities reported the highest level of SB (83.6%), whereas those who assessed their problem lower had lower SB (69.4%, 57.3%, 44.5%, and 31.6% respectively). (See Figure 5.2 and 5.3)

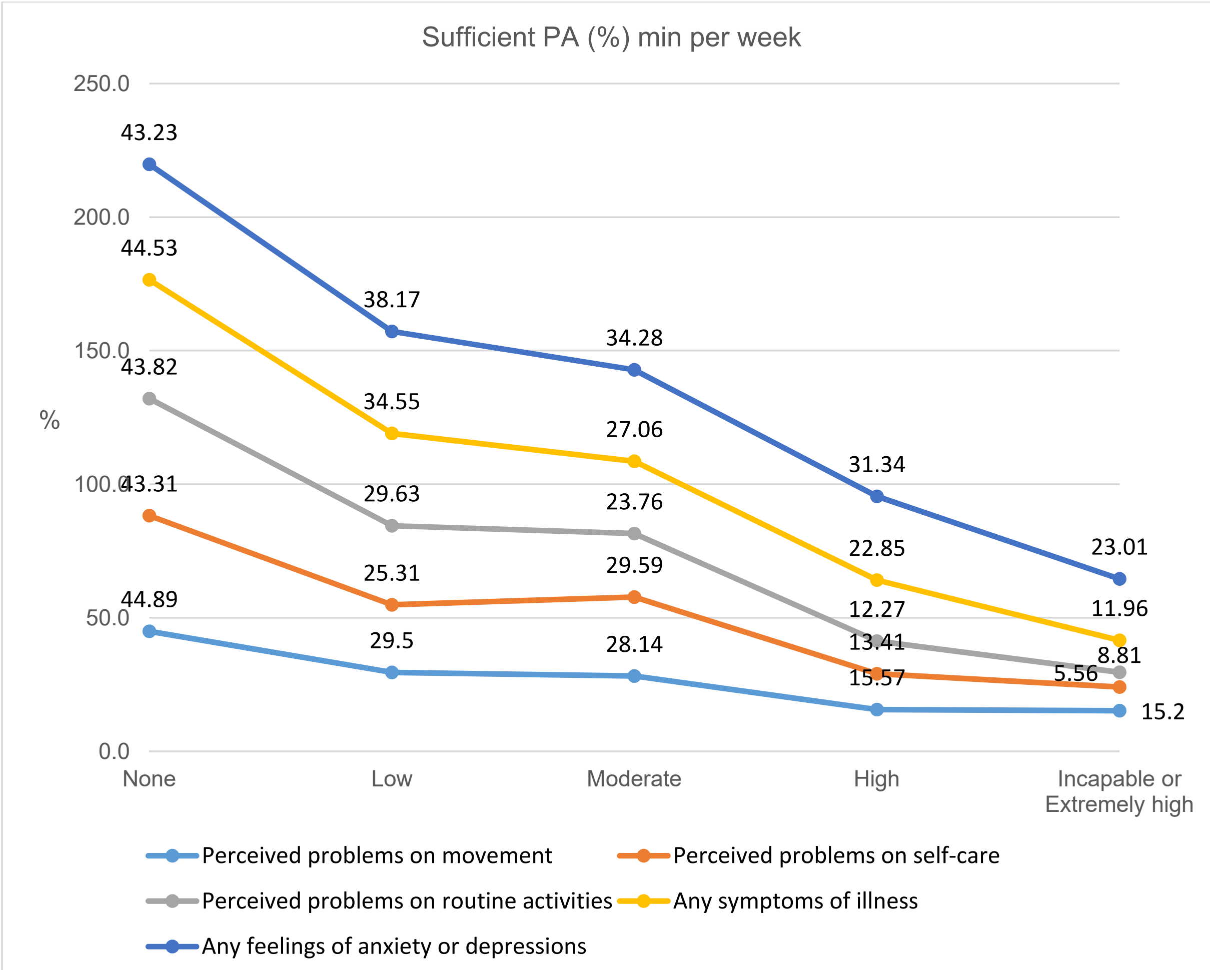

Figure 5. 2 Sufficient physical activity by health status

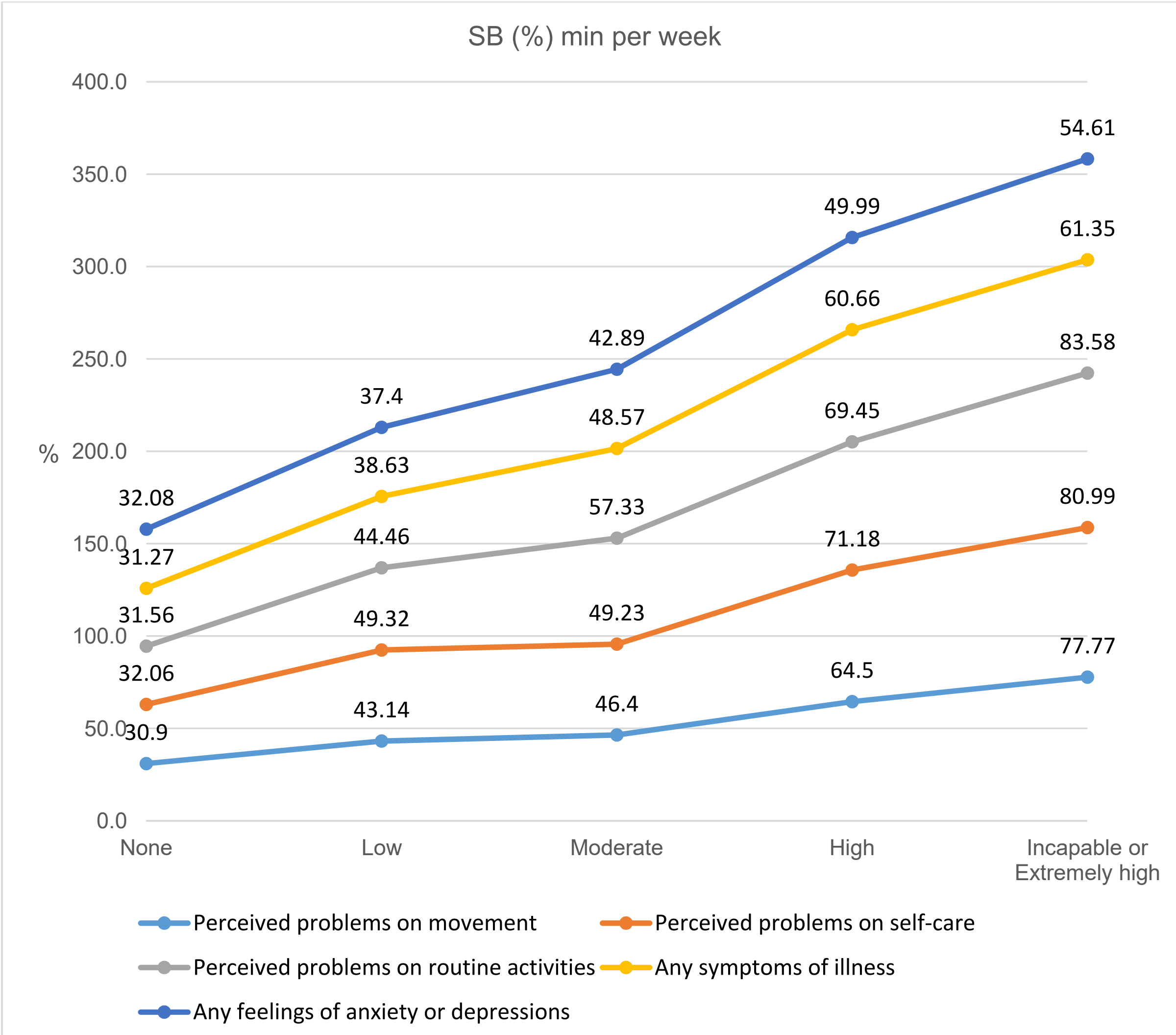

Figure 5. 3 Sedentary behaviour by health status

Factors related to sufficient physical activity and sedentary behaviour

When analysed in a logistic regression, we found males, younger age, high education level, and occupation independently increased the probability of having sufficient PA especially working in agriculture/fishery, factory, and labour work. These occupations increased the probability 3.54, 2.02, and 3.99 times, respectively, when compared with being unemployed. Conversely, having underlying diseases and self-rated health problems decreased the probability of having sufficient PA. For example, participants who rated problems at the high or highest level on routine activities decreased the probability of having sufficient PA 46% and 95% respectively when compared with those who rated no problem. However, in self-rated problems on depression, the higher level of the problem significantly increased the probability of having sufficient PA. In other words, participants who had high, moderate, and low feelings of anxiety or depression were 87%, 26%, and 15% more likely to have sufficient PA respectively.

Being male, compared with female, decreased the probability of having high SB by 16%. Being employed also decreased the probability of having high SB particularly as labourers in agriculture/fishery. They had by 66% lower levels of SB than those who were unemployed. In addition, higher education level decreased the probability of high SB by 18% and 26% when compared with secondary or high school and none or primary school, respectively. Participants aged 51 and over had 50% higher probability of high SB than younger ages (18-34 years old). The higher perception of health problems on movement and routine activities increased the probability of high SB. For example, participants who perceived high level of problems on movement and routine activities were 3.54 and 3.63 times more likely, respectively, to have high SB than those who rated none. In contrast, participants who assessed their depression problem high, moderate, and low were 48%, 30%, and 14% less likely, respectively, to have SB than those who did not perceive this problem. (See Table 5.2)

Table 5. 2 Factors related to sufficient physical activity and sedentary behaviour

Variable	Sufficient physical activity			Sedentary behaviour		
	%	OR	95% CI	%	OR	95% CI
Gender						
Female	36.2	1.00		37.4	1.00	
Male	49.2	1.42*	(1.35-1.49)	29.9	0.84*	(0.79-0.88)
Age groups						
18-34 years	46.8	1.00		29.3	1.00	
35-50 years	45.6	0.89*	(0.82-0.98)	28.2	1.10	(1.00-1.20)
51 years and over	33.8	0.69*	(0.63-0.76)	43.6	1.50*	(1.36-1.65)
Household area						
Non-municipal area	43.2	1.00		34.3	1.00	
Municipal area	41.6	1.01	(0.96-1.06)	33.1	1.01	(0.96-1.06)
Regions						
Bangkok	45.4	1.00		29.3	1.00	
Central	39.1	0.67*	(0.59-0.76)	35.6	1.49*	(1.31-1.70)

Variable	Sufficient physical activity			Sedentary behaviour		
	%	OR	95% CI	%	OR	95% CI
North	45.5	0.99	(0.87-1.13)	34.0	1.13	(0.99-1.29)
Northeast	42.1	0.66*	(0.58-0.75)	33.7	1.28*	(1.12-1.46)
South	43.6	0.67*	(0.59-0.77)	34.2	1.48*	(1.29-1.69)
Highest education levels						
None or primary school	39.9	1.00		37.1	1.00	
Secondary or high School	46.2	1.19*	(1.11-1.28)	30.3	0.82*	(0.77-088)
College or higher	42.7	1.28*	(1.16-1.41)	31.1	0.74*	(0.68-0.82)
Occupation						
Unemployed	28.8	1.00		46.1	1.00	
Executives	41.8	1.79*	(1.59-2.01)	32.3	0.60*	(0.53-0.67)
Clerks	39.7	1.46*	(1.18-1.79)	31.6	0.62*	(0.51-0.77)
Service and commercial workers	43.1	1.86*	(1.71-2.02)	33.1	0.62*	(0.58-0.68)
Workers in agriculture/fishery	54.0	3.54*	(3.28-3.82)	25.3	0.34*	(0.32-0.37)
Workers in factory and production	45.2	2.02*	(1.83-2.22)	28.9	0.54*	(0.49-0.59)
Labourers and other basic jobs	56.5	3.99*	(3.58-4.45)	25.0	0.34*	(0.31-0.38)
Asset of Quintiles						
Lowest quintile (Q1)	40.9	1.00		32.7	1.00	
Second quintile (Q2)	42.0	0.98	(0.91-1.06)	33.7	1.03	(0.96-1.12)
Third quintile (Q3)	44.2	1.00	(0.93-1.08)	33.6	1.10*	(1.02-1.18)
Fourth quintile (Q4)	45.4	1.07	(0.99-1.17)	32.3	1.04	(0.96-1.13)
Highest quintile (Q5)	40.8	1.10*	(1.01-1.21)	34.7	1.02	(0.93-1.11)
Having underlying diseases						
No	45.4	1.00		31.0	1.00	
Yes	31.8	0.94*	(0.88-1.00)	44.1	0.98	(0.93-1.04)
Self-rated health status						
Perceived problems on movement						
None	44.9	1.00		30.9	1.00	

Variable	Sufficient physical activity			Sedentary behaviour		
	%	OR	95% CI	%	OR	95% CI
Low	29.5	0.79*	(0.72-0.87)	43.1	1.10*	(1.01-1.20)
Moderate	28.1	0.77*	(0.65-0.92)	46.4	1.21*	(1.04-1.41)
High	15.6	0.72	(0.49-1.07)	64.5	2.02*	(1.45-2.82)
Unable to perform related tasks	15.2	0.23	(0.05-1.07)	77.8	3.54*	(1.46-8.61)
Perceived problems on self-care						
None	43.3	1.00		32.1	1.00	
Low	25.3	0.78*	(0.67-0.90)	49.3	1.26*	(1.11-1.43)
Moderate	29.6	1.01	(0.76-1.35)	49.2	1.09	(0.85-1.40)
High	13.4	0.78	(0.38-1.57)	71.2	1.51	(0.87-2.64)
Unable to perform related tasks	8.8	2.95	(0.30-28.67)	81.0	0.95	(0.22-4.12)
Perceived problems on routine activities						
None	43.8	1.00		31.6	1.00	
Low	29.6	0.92	(0.81-1.04)	44.5	1.26*	(1.13-1.40)
Moderate	23.8	0.90	(0.68-1.19)	57.3	1.59*	(1.25-2.02)
High	12.3	0.54*	(0.32-0.94)	69.5	1.85*	(1.22-2.82)
Unable to perform related tasks	5.6	0.05*	(0.01-0.50)	83.6	3.63*	(1.56-8.45)
Any symptoms of illness						
None	44.5	1.00		31.3	1.00	
Low	34.5	1.02	(0.94-1.11)	38.6	0.88*	(0.82-0.95)
Moderate	27.1	0.86	(0.71-1.03)	48.6	1.02	(0.86-1.20)
High	22.8	0.94	(0.64-1.39)	60.7	1.09	(0.77-1.53)
Extremely high	12.0	0.39	(0.08-1.79)	61.3	1.32	(0.43-4.08)
Any feelings of anxiety or depressions						
None	43.2	1.00		32.1	1.00	
Low	38.2	1.15*	(1.06-1.25)	37.4	0.86*	(0.80-0.93)
Moderate	34.3	1.26*	(1.03-1.53)	42.9	0.70*	(0.58-0.84)
High	31.3	1.87*	(1.28-2.74)	50.0	0.52*	(0.36-0.75)

Variable	Sufficient physical activity			Sedentary behaviour		
	%	OR	95% CI	%	OR	95% CI
Extremely high	23.0	2.81	(0.89-8.92)	54.6	0.66	(0.24-1.86)

Note: OR = odds ratio; CI = confidence interval; *p-value < 0.05

Discussion

We found only 42.4% of the Thai population aged 18 and over had sufficient PA, which is lower than other studies conducted in the past decade [6-11] and worldwide [3]. Although the same questionnaire (GPAQ) was used [9-11], the sample in the present study was population-representative and recruited from all over the country. A large sample size of around 140,000 participants was included, while past surveys included smaller numbers of participants (about 8,000 – 30,000). The results were, therefore, different even with the same tool [7]. Moreover, the criteria used to calculate the sufficient PA level was different among studies. This study referred to the PA level recommended by WHO (at least 600 MET-minutes/week). Our findings show that the PA level in the Thai population has reached only half of the target of 10% physical inactivity reduction or 84%, it was expected to achieve by 2025 [12]. This can be partly explained by the past campaigns that mainly focused on PA in the recreation domain and to only some specific population groups [16-18]. Many studies at the national and international level also suggested that the energy from PA was least expended in leisure time when compared with the other domains [16, 19-21]. The rising trend of sedentary lifestyles is another explanation of low PA level in the Thai population [11]. This suggests that Thai PA promotion policies should be more comprehensive and improved to include all activity areas, especially occupation and transportation domains. Most Thai people already spend a great deal of time in these two domains in their daily routine and with recent changes in lifestyles, they tend to have high SB [15, 16, 21, 22]. Therefore, effective interventions to increase PA and reduce SB are needed.

We found 33.8% of the Thai population had high SB. This may explain the lower level of sufficient PA in the Thai population. With modern lifestyles and advanced technology, people tend to sit longer hours using mobile phones and computers, watching TV, and driving to work [15]. Our findings of high SB confirm the results from a study by the Institute for Population and Social Research showing that Thai people spend 13.4 hours per day in SB [11] and this may suggest less time in PA. Previous studies support an association between SB and negative health outcomes [33, 34]. Even with sufficient PA, people are still at risk of NCDs such as cardiovascular diseases, diabetes, cancers, and metabolic syndrome if they have prolonged sitting [33, 34]. In children and adolescents, higher time of SB also affects their muscle strength, social skills, and academic performance [35].

PA promotion and SB reduction are now an urgent agenda for public health. It is highly recommended to substitute SB time with PA especially in the workplace and during transportation. Some practices or interventions can be promoted in the workplace such as breaking SB by standing at every one hour, and using stairs instead of an elevator. More active means of transportation can also be encouraged, for example, walking to the market, cycling or using public transportation to work such as a speed train, bus, and subway train. Active behaviours related to transportation can also be promoted, for instance, getting off a bus one stop before a destination, and parking farther from an entrance to a building. These practices and behaviours if adapted into Thai lifestyles can increase PA and reduce SB. At the policy level, the Thai Government and private health corporations can invest in transportation infrastructure, public green environment, and active workplace [15, 16, 21, 22, 34, 35].

We also found associations between high levels of sufficient PA (49.2% - 56.5%) and low levels of SB (25.0% - 29.9%) in males, labourers in agriculture/fishery, and factory workers. Due to higher energy expenditure in these population groups and working conditions, they are in an environment enabling higher PA. However, we should still promote PA in these groups. Older adults, unemployed, and those who reported having underlying diseases, had low levels of sufficient PA (28.8% - 33.8%) and high levels of SB (43.6% - 46.1%). This may also be explained by their lifestyles and conditions. They are likely to stay in their household which is less conducive to movement. Their health problems may also prevent them from taking part in vigorous PA [20, 23-26]. These groups of people are at risk of NCDs [15, 27] and need interventions to change their SB time to light or moderate PA, particularly in household, transportation, and recreation domains. They should also be informed of a high risk of NCDs from high sitting time. Therefore, reducing SB can help reduce the economic burden of NCDs and other related medication costs [4, 12].

Regarding the associations between health status and PA and SB behaviours, participants who reported no underlying diseases and lower severity of health problems had higher sufficient PA level and lower SB than those who did. Health problems can impact muscles used for movements and this may be a major obstacle to PA participation [3, 16, 25, 27]. Except for anxiety and depression problems, a positive association was found in more severe problems. Moreover, when considering factors that were associated with sufficient PA and reduced SB, these included non-modifiable factors such as sex, age, education level, and occupation. However, these factors cannot be changed. But our findings still indicate high-risk population groups and a degree of risk in each subgroup. For example, older adults are likely to have less PA, and people with sedentary jobs tend to have high overall SB. These findings can facilitate a development of a more specific and effective public health program to the targeted populations at risk.

A limitation of the study is the use of a self-report tool, GPAQ. The recall bias of the study participants needs to be recognised. The reported time spent in different activities that were not correctly remembered may present higher or lower estimates than actual values [11, 16, 31]. However, the present study reduced recall bias that may occur by setting the possible values of daily PA and SB. Another limitation was from the questionnaire that needed to be translated into Thai and some examples cited in GPAQ [5] were missing in the Thai version. This may lead to misunderstanding of SB and its reported values. It is important that future surveys improve the translation and provide clear examples to ensure that participants fully understanding the questions. Moreover, future studies should also consider using device-based instruments (e.g., accelerometer) which is now available in Thailand in order to provide more accurate movement information [32].

Conclusion

Based on the 2015 Health and Welfare Survey, 42.4% of Thai people aged 18 and over met the recommended PA level, while 33.8% had high SB. Sociodemographic factors found to be associated with a high level of sufficient PA and a low level of SB were being male, working in agriculture/fishery or factory or as labourers, and reporting no underlying diseases. On the other hand, factors associated with a low level of sufficient PA and high SB were older age, being unemployed, and having underlying diseases. Our findings can be used to guide policy development to promote PA and reduce SB with a greater focus on PA promotion in the occupation and transportation domains. For SB reduction, we should place more attention on older adults, the unemployed, and people who reported having underlying diseases. These population groups potentially have low PA and high SB and need specific interventions to increase their movement levels. It is also highly encouraged that the assessment of PA level in the Thai population be improved to provide more accurate data of population-based PA levels which is a prerequisite to effective interventions.

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CHAPTER VI: Correlates of Physical Activity and Sedentary Behaviour in the Thai Population: A Systematic Review

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DECLARATION OF CO-AUTHORSHIP AND CO-CONTRIBUTION: PAPERS INCORPORATED IN THESIS BY PUBLICATION

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Correlates of Physical Activity and Sedentary Behaviour in the Thai Population: A Systematic Review

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Abstract

Background

Given the importance of knowing the potential impediments and enablers for physical activity (PA) and sedentary behaviour (SB) in a specific population, the aim of this study was to systematically review and summarise evidence on individual, social, environmental, and policy correlates of PA and SB in the Thai population.

Methods

A systematic review of articles written in Thai and English was conducted. Studies that reported at least one correlate for PA and/or SB in a healthy Thai population were selected independently by two authors. Data on 21 variables were extracted. The methodological quality of the included studies was assessed using the Newcastle-Ottawa Scale.

Results

A total of 25,007 records were screened and 167 studies were included. The studies reported associations with PA for a total of 261 variables, mostly for adults and older adults. For most of the variables, evidence was available from a limited number of studies. Consistent evidence was found for individual-level and social correlates of PA in children/adolescents and adults and for individual-level correlates of PA in older adults. Self-efficacy and perceived barriers were consistently associated with PA in all age groups. Other consistently identified individual-level correlates in adults and older adults included self-rated general health, mental health, perceived benefits, and attitudes towards PA. Consistent evidence was also found for social correlates of PA in adults, including social support, interpersonal influences, parent/family influences, and information support. The influence of friendship/companionship was identified as a correlate of PA only in children/adolescents.

A limited number of studies examined SB correlates, especially in older adults. The studies reported associations with SB for a total of 41 variables. Consistent evidence of association with SB was only found for obesity in adults. Some evidence suggests that male adults engage more in SB than females.

Conclusions

More Thai studies are needed on (i) PA correlates, particularly among children/adolescents, and that focus on environment- and policy-related factors and (ii) SB correlates, particularly among older adults. Researchers are also encouraged to conduct longitudinal studies to provide evidence on prospective and causal relationships, and subject to feasibility, use device-based measures of PA and SB.

Keywords: Correlates, Physical activity, Sedentary behaviour, Systematic review, Thailand

Background

Even though physical activity (PA) has been identified as the ‘best buy’ in public health [1] and national actions for the promotion of PA have been employed in many countries [2], population levels of PA are still declining [2-4]. In contrast, time spent performing sedentary behaviour (SB) is increasing [3, 4]. SB refers to any waking activity in a sitting, reclining, or lying position with low energy expenditure [5]. In the academic literature, SB has been conceptualised in two ways: (i) as a health risk factor ‘independent’ of PA [6]; and (ii) as a part of the time-use composition consisting of sleep, SB, and PA co-dependent time-use components [7]. In both conceptualisations, SB is deemed a potentially important factor for population health. Nevertheless, there seem to be barriers to the promotion of PA and reduction of SB, especially in low- and middle-income countries. These barriers include workforce shortages in the PA/SB sector (e.g. lack of PA promoters), weak networks of collaboration with other sectors (e.g. education, sports, and transportation), the lack of effective actions, and lack of knowledge about what approaches to PA promotion and SB reduction are feasible [2, 8]. These have been major challenges in Thailand, where efforts have been made to design and implement policy-level interventions.

To develop effective programs or interventions to increase PA and reduce SB, there is a need to understand correlates of these behaviours in specific populations. Public health experts advise that this need is urgent in low- and middle-income countries [2, 9]. Moreover, given substantial differences between geographical areas in social, cultural, environmental, and economic factors, it is important to explore PA and SB correlates in specific countries so that feasible interventions can be developed and designed based on local data [10]. Studies on PA correlates in low- and middle-income countries have recently started receiving more attention [2, 9-13]. Since 1987, and especially over the last two decades, PA has been the focus of a plethora of Thai epidemiological research, and the attention has most commonly been placed on its correlates [14].

In Thailand, the data from a 2015 population-representative survey on PA and SB showed that 21-25% of Thai children and adolescents (aged 6–17 years) achieved the recommended level of PA (i.e. 60 minutes a day) [15]. In addition, more than 78% of Thai children and adolescents engaged in two or more hours of SB [15]. Around 40% of Thai adults (aged 18 and above) met the World Health Organisation (WHO) recommendations for moderate-to-vigorous PA (MVPA) [16, 17]. Interestingly, 33.8% of Thai adults reported a high level of SB and no MVPA in the past week [16]. A better understanding of what makes some Thai population groups less active than others may help tackle the problem of insufficient PA.

Like other healthy behaviours, PA and SB are influenced by many factors [9, 18-22]. However, the focus to date has mostly been on individual-level correlates, such as sex, age, attitude, and self-rated general health [9, 11, 14, 20-22]. The social-ecological approach has been widely adopted to understand the interrelationships among multiple factors that contribute to PA and SB, including individual, social, environmental, and policy factors [9, 18-22]. The full spectrum of PA/SB correlates has been analysed in several reviews, mostly in high-income countries such as the United States, Australia, and Canada [9, 20-25]. Studies from low- and middle-income countries including Thailand have rarely been included [9, 20-25].

Given the importance of knowing which variables are associated with PA and SB in a specific population, the aim of this study was to systematically review and summarise the available evidence on individual, social, environmental, and policy correlates of PA and SB in Thai children, adolescents, adults, and older adults. We also aimed to identify the key gaps in the literature on PA and SB correlates in Thailand and provide recommendations for future research.

Methods

Search strategy

This systematic review was conducted by following the PRISMA guidelines [26]. The primary literature search was conducted from database inception to September 2016 using the following ten bibliographic databases: Academic Search Premier; CINAHL; Health Source: Nursing/Academic Edition; MasterFILE Premier; PsycINFO; PubMed/MEDLINE; Scopus; SPORTDiscus; Web of Science; and the Networked Digital Library of Theses and Dissertations (NDLTD). The secondary literature search was conducted by using three main sources, including: the Google and Google Scholar internet search engines (using search terms in both Thai and English); references of the studies that were selected in the primary search; and the websites/databases of Thai health-related organizations and institutes including the Division of Physical Activity, Ministry of Public Health; Thai Health Promotion Foundation; Health System Research Institute; Physical Activity Research Institute; Thai National Research Repository; Thai Thesis Database; Thai NCD Network; Kasetsart University Research; Chulalongkorn University Intellectual Repository; and Institute for Population and Social Research, Mahidol University.

Study selection and inclusion criteria

Two researchers (NL and KS) independently screened all references obtained from the search results, removed duplicates, and selected studies. The third author (ZP) resolved discrepancies about the study selections. The eligibility criteria included the following: Published peer-reviewed journal papers, theses, reports, and conference papers written in Thai or English were included, and reviews, commentaries, and editorials were excluded. Observational studies (cross-sectional, case-control, and prospective) that targeted healthy Thai people (as opposed to patients with a specific disease or health condition) of any ages were considered eligible for inclusion. To be included, the studies had to present the association of at least one variable with total PA (e.g. minutes per day or METs per week), MVPA, moderate PA (MPA), vigorous PA (VPA), meeting/not meeting PA guidelines (e.g. meeting the PA recommendation of 60 minutes of MVPA per day), domain-specific PA (e.g. recreation, transportation), and exercise participation. For SB measures, total SB or sitting time or frequency and/or duration in one or more of sedentary activities including television (TV) viewing, screen time, and computer/internet use were included. Both self-reported and devise-based measurements qualified for inclusion. Longitudinal studies that analysed PA or SB as predictors of an outcome variable, were not considered eligible for inclusion.

Data extraction

The following data were extracted from the selected studies: (a) general bibliographical information, such as publication type and language; (b) research methods used, including sampling techniques; (c) characteristics of the study population such as sex, age, and region; (d) description of PA/SB measure, including the PA type as a dependent variable and validity information; (e) specific correlate(s) with an assigned, categorized domain such as socio-demographic, psychological, and social factors; and (f) the type of statistical analysis used in the included studies. Data were extracted separately for three age groups: children and adolescents (<18 years old); adults (between 18 and 59 years old); and older adults (>60 years old). The full extraction tables are provided in the Additional File 1.

Data coding and pooling

To pool the results of individual studies, we used the procedure proposed by Sallis et al. [24]. The pooled associations between potential correlates and PA and SB were classified as: a) mostly positive associations (denoted by '+'); b) mostly negative associations (denoted by '-'); or c) mostly non-significant, indeterminate, or inconsistent associations (denoted by '?'). The codes were determined based on the percentage of significantly positive, significantly negative, and non-significant associations, according to the rules presented in Table 6.1 [24]. The classification system was slightly adapted from the original categorisation used by Sallis et al. [24], to better reflect the implication of non-significant relationships. The results from the most adjusted analysis reported in a paper were used for the classification. Letters 'M' and 'F' were used to indicate findings for male and female participants when results were reported separately for sexes.

Table 6. 1 Rules applied to classify correlates of physical activity

Percentage of studies (%)*	**Code describing the association between a correlate and PA or SB†**	**Meaning of the code**
0 - 59	?	Mostly non-significant, indeterminate, or inconsistent associations
60 - 100	+ or –	Mostly positive (+), or negative (–) associations

*Percentage of studies showing positive, negative, or non-significant association

†When four or more studies showed positive or negative association, the summary results were coded as ++, and --, respectively. The code "??" denoted a frequently studied correlate whose association with PA or SB was largely inconsistent across the studies.

A synthesis of the findings of this review was structured by applying the social-ecological model of PA/SB, where all correlates were categorised into key components of the model including individual (e.g. socio-demographic, biological), social (e.g. interpersonal, cultural), physical environment (e.g. facilities, neighbourhood), and policy (e.g. education and workplace policies) factors. The pooled results are presented separately for children and adolescents (6-17 years), adults (18-59 years), and older adults (60 years and over). We used this threshold for the 'older adults' group, because, according to the Thai Labour Protection Act, the retirement age applies to adults aged 60 years and more [27].

Risk of bias

The methodological quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) [28]. NOS was designed to evaluate the quality of observational studies for several purposes, such as to include/exclude studies for meta-analysis, weight studies, and address areas that need methodological improvements [29]. The three aspects of studies that were assessed using the NOS tool included the selection of study groups (4 items, maximum 5 points), adjustments for potential confounders (1 item, maximum 2 points), and ascertainment of exposure and outcomes (2 items, maximum 3 points) [28, 29]. The overall score was calculated as the sum of points across the three categories. The overall scores were classified into three groups: low (<5 points), moderate (5-7 points), and high (>7 points) study quality [30].

Results

Characteristics of the included studies

The search and study selection processes are illustrated in Figure 6.1. A total of 25,007 records were identified. Of these, 167 papers met the eligibility criteria and were included in the present review. Most studies focused on PA only (76%; *n* = 127), 15 studies (9%) examined SB correlates only, and 25 studies (15%) examined correlates of both PA and SB. The included articles were published between 1993 and 2016. All studies used a cross-sectional design. The average sample size cited in the studies was 3,317 and ranged from 27 to 87,134. Two studies included only male participants (1.2%), 17 studies included only female participants (10.2%), and the remainder included both sexes (88.6%; *n* = 148). Half of the studies were conducted among adults (50.3%; *n* = 100), followed by older adults (28.6%; *n* = 57) and children/adolescents (21.1%; *n* = 42). Of these, twenty-nine studied on adults/older adults and three on adolescents/adults. Most of the included publications were articles published in peer-reviewed journals (69.5%; *n* = 116), more than a quarter were doctoral and master's theses (26.9%; *n* = 45), and the remaining publications were reports (2.4%; *n* = 4) and conference papers (1.2%; *n* = 2).

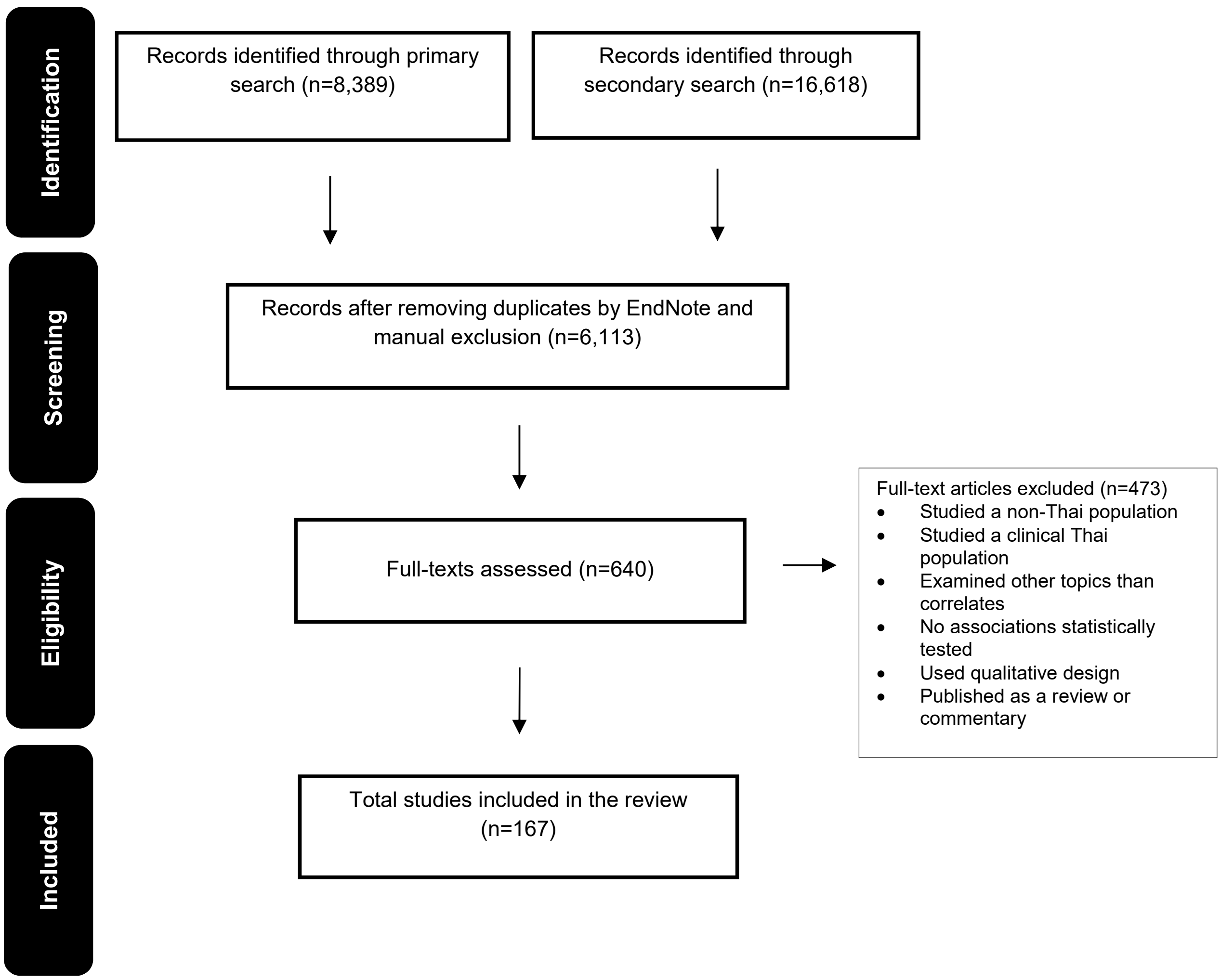

Figure 6. 1 Flow diagram of study selection process

Nearly all studies were conducted using self-report instruments to measure PA (97.6%; *n* = 163). Three studies used accelerometers (1.8%) and one study used pedometers (0.6%). Sixty-three percent of the studies used previously validated PA measures (*n* = 96). More than half of the studies measured exercise participation (54.9%; *n* = 89), followed by MVPA (19.1%;

n = 31) and total PA (13.6%; *n* = 22). Domain-specific PA was assessed in 6.8% of the studies (*n* = 11), which mainly included recreation and household PA. The remaining studies assessed VPA (3.1%; *n* = 5) and MPA (2.5%; *n* = 4). Supplementary Tables 1-22 presenting correlates of each PA type separately are available in the Additional File 2.

SB was assessed using self-report instruments in all but one study. Most instruments used to measure SB had been previously validated (62.5%; *n* = 25). Watching television was the main SB independently investigated in several studies (30.6%; *n* = 15), followed by total SB time (20.4%; *n* = 10). Other individual sedentary activities included computer and internet use that were examined in 16.3% (*n* = 8) and 10.2% (*n* = 5) of the studies respectively. Screen time, which refers to TV viewing and computer use combined, was assessed in 12.2% of the studies (*n* = 6). The remainder observed the total duration of sitting during leisure time (6.1%; *n* = 3) and at work (4.1%; *n* = 2).

Methodological quality

The median overall score of the included studies on the NOS was 6 ('moderate quality'). Twenty-three studies were categorised as 'high quality', 34 were considered 'low quality', while the remainder were of moderate quality (*n* = 110). Among the high-quality studies, seven studies dealt with children and adolescents, seven focused only on adults, two only on older adults, and seven on both adults and older adults. It was, therefore, not considered appropriate to perform a sensitivity analysis using only findings from high-quality studies, due to the fact that too few of these studies were available. The results of the quality assessment for all the included studies can be found in the APPENDIX III.

Physical activity correlates

The included studies reported associations with PA for a total of 261 variables [32-53, 55-60, 62-66, 68-74, 76-83, 85-90, 92-101, 103-105, 107-140, 142-146, 150-155, 157-170, 172, 174-197]. Almost half of the variables were significantly associated with PA (47.5%; *n* = 124). Multiple factors were assessed, including individual, social, physical, and policy environment variables. The most frequently studied factors were those at the individual level (81.6%; *n* = 213). The statistically significant correlates most often included psychological factors, followed by biological, demographic, and health behavioural and lifestyle factors (Figure 6.2).

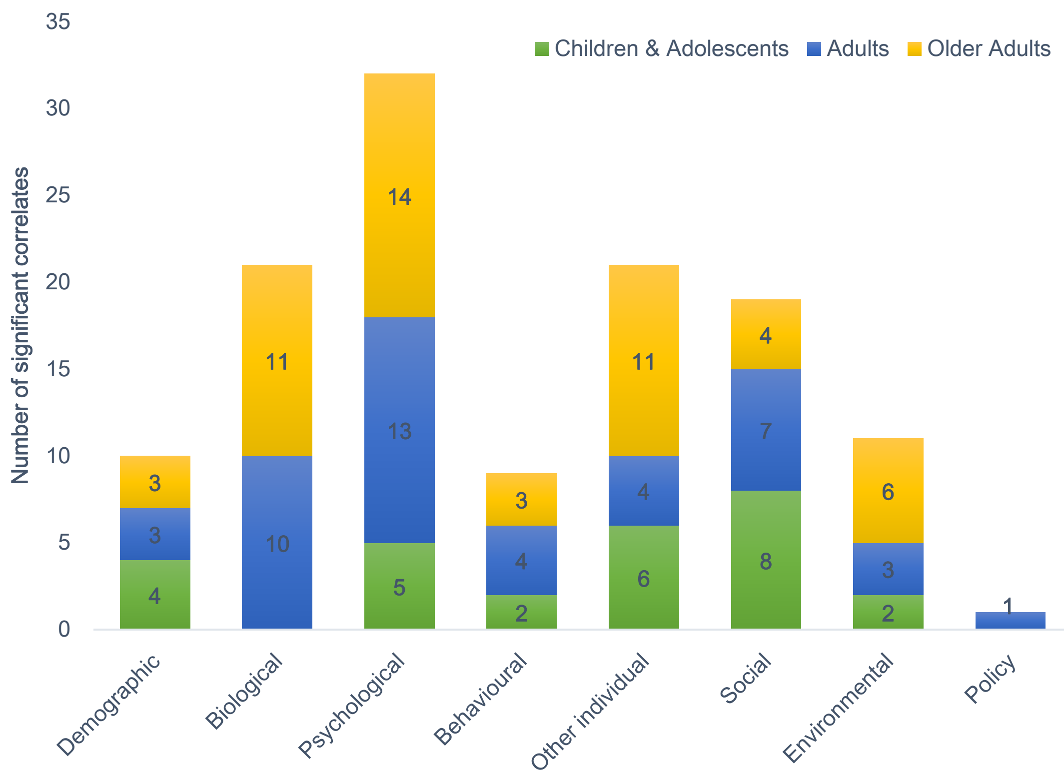

Figure 6. 2 The number of significant correlates of physical activity across different categories

Correlates of children's and adolescents' physical activity

A total of 52 potential PA correlates were studied in Thai children and adolescents (Table 6.2). Consistent evidence of association with higher PA was found for the following individual-level factors: younger age, being a male, higher self-efficacy, and lower perceived barriers. Consistent evidence of association with higher PA was found for the social factor of greater friendship/companionship influences. No consistent evidence was found for environmental and policy correlates of PA.

Some evidence supported associations between higher PA and the following individual-level factors: lower household income, going to mixed-gender schools (compared with single-gender schools), higher self-rated general health, greater enjoyment of PA/exercise, more past PA/exercise experience, higher resilience, higher perceived physical competence, greater knowledge of PA/exercise, not having asthma and hypertension, lower body dissatisfaction, lower duration of TV viewing, and lower grade point average. Some evidence supported associations between higher PA and the following social factors: greater parent/family influences, more involvement with friends, ease in making friends, better social supports, greater teacher influences, greater general interpersonal influences, and better information support. Some evidence supported associations between higher PA and the following environmental factors: better environmental supports, and better neighbourhood environment. No evidence was found for policy correlates of PA.

The associations between PA and school grade and body mass index (BMI) were mostly non-significant or largely inconsistent.

Table 6. 2 Summary of evidence on physical activity (PA) correlates in Thai children and adolescents (6 – 17 years old)

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age	97, 135 (M, F), 183		158 (M, F)	--
– Sex (+ denotes males are more active, - denotes females are more active)		51, 55, 97, 111, 118, 122, 126, 135, 158, 167, 178, 183	169, 189	++
– Household income	96, 178			-
– School type (+ denotes more PA in mixed-gender schools, - denotes more PA in single-gender schools)		55		+
– School grade	80		51, 118, 167, 189	??
– Parents' occupation			189	?
– Municipality (+ denotes more PA in an urban place of residence, - denotes more PA in a rural place of residence)		169	135 (M, F), 64	?
– Household location within Bangkok			178	?
Biological factors				
– Body weight			135 (M, F)	?
– Body mass index (BMI)	97, 178		33, 51, 135 (M, F), 158	??
– Parents' BMI			178	?
– Underweight			110	?
– Overweight	110, 157	111 (F)	52, 111 (M), 125 (F)	?
– Obesity	110, 130 (M), 157		125 (F), 130 (F), 169	?
– Body fat (%)		135 (M)	135 (F)	?
– Height	135 (M, F)		77 (M, F)	?
– Low-density lipoprotein cholesterol (LDL-C) level			158	?

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Systolic blood pressure			158	?
– Diastolic blood pressure			158	?
– Dietary fat intake			158	?
Physical health				
– Asthma	157			-
– Hypertension	157			-
General health				
– Self-rated general health		121 (M, F)		+
– Child's health status as perceived by parents			45	?
Psychological factors				
– Self-efficacy		45, 51, 80, 123	167	++
– Perceived benefits of PA/exercise		51, 80	38 (M, F), 167	?
– Perceived barriers for PA/exercise	38 (F), 51, 80, 123		38 (M), 167	--
– Attitudes towards PA/exercise		178	167	?
– Self-esteem			167	?
– Cues to action			38 (M, F)	?
– Being bullied	129 (M)		129 (F)	?
– Expected outcomes of PA/exercise			167	?
– Body dissatisfaction	55			-
– Enjoyment of PA/exercise		80, 183	178	+
– Resilience		118		+
Physical skills, abilities, and fitness				
– Perceived physical competence		183		+
Health behavioural and lifestyle factors				
– Past PA/exercise experience		51, 80	167	+
– TV viewing	178			-
Knowledge				
– Knowledge about PA/exercise		167		+
– Parents' knowledge about school-aged children's PA			45	?
Academic/school performance				
– Grade point average	157			-
Social environment				
Social and cultural factors				
– Social support		123, 178	167	+
– Parent/family influences		80, 183	178	+
– Friendship/companionship influences		80, 122 (M, F), 183		++

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Involvement with friends		122 (M, F)		+
– Ease in making friends		122 (M, F)		+
– Teacher influences		80		+
– General interpersonal influences		51		+
– Information support (e.g. social media)		167		+
Physical environment				
Environmental factors				
– Environmental support (e.g. situational influences)		51, 80, 178		+
– Supportive physical environment (e.g. facilities, supplies)		178	167	?
– Supportive neighbourhood environment		178		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

Correlates of adults' physical activity

In total, 120 potential correlates of PA were studied in Thai adults (Table 6.3). Consistent evidence of association with higher PA was found for the following individual-level factors: higher self-rated general health, better mental health, positive attitudes towards PA/exercise, higher self-efficacy, higher perceived benefits of PA/exercise, lower perceived barriers for PA/exercise, and more spare time. Consistent evidence of association with higher PA was found for the following social factors: better social support, greater general interpersonal influences, greater parent/family influences, and better information support. No consistent evidence was found for environmental and policy correlates of PA.

Some evidence supported associations between higher PA and the following individual-level factors: being underweight, higher HDL-cholesterol level, higher VO_2Max, lower triglycerides (TG) level, lower total cholesterol: HDL-C ratio, lower risk of having high TG, lower resting heart rate, lower haematocrit level, lower age-related macular degeneration, more years of working experience, having a 'dream job', ever attended a workshop on exercise, higher dietary calcium intake, higher sunlight exposure, having osteoporosis, greater overall health belief, higher career satisfaction, higher intrinsic motivation, healthier dietary habits, past PA/exercise experience, more enjoyment of PA/exercise, higher outcome expectancies, greater intention to take part in PA/exercise, better physical and functional fitness, engaging in enjoyable sports, lower extrinsic motivation, and lower stress level. Some evidence supported associations between higher PA and the following social factors: better cultural support, family members' involvement in PA/exercise, and greater friendship/companionship influences. Some evidence of association with higher PA was found for the following environmental factors: less exposure to urban environment, later months of a calendar year (compared with the other months), and shorter distance to shopping place. Some evidence supported association between higher PA and the policy factor of better supportive education policies.

The associations between PA and age, sex, marital status, education level, university year, faculty, household income, occupation, campus/working location, BMI, being overweight, obesity, history of sickness, and knowledge of PA/exercise were mostly non-significant or largely inconsistent.

Table 6. 3 Summary of evidence on physical activity (PA) correlates in Thai adults (18 – 59 years old)

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age		37, 58, 59, 107, 124, 140, 172	58, 72, 81, 112, 116, 117, 155, 176, 190, 197	??
– Sex (+ denotes males are more active, - denotes females are more active)	50, 100, 155, 196	31, 83, 87, 100, 107, 113, 116, 117, 131, 132, 136, 150, 159, 165, 180, 181, 184, 186, 190, 193, 195	36, 44, 58, 59, 72, 92, 95, 112, 124, 140, 172, 176, 194, 197	??
– Municipality (+ denotes more PA in an urban place of residence, - denotes more PA in a rural place of residence)	58		58	?
– Marital status (+ denotes singles are more active)		155	58, 59, 72, 81, 101, 112, 117, 172, 190, 197	??
– Education level	58, 116, 117, 181	59, 155, 190	58, 72, 101, 112, 172, 197	??
– University year	165	137, 186	36, 95, 179, 193, 195	??
– Faculty*		44, 87, 165, 194, 195, 196	92, 95, 159, 179, 186	??
– Household income	117	58, 92	58, 59, 72, 101, 172, 179, 181, 190, 195, 197	??
– Occupation (+ denotes unemployed are more active)		155, 190	58, 59, 101, 117	??
– Region (+ denotes Central including Bangkok residents are more active, - denotes residents of other provinces are more active)	134	155	172	?

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Early-life (0-5) urban exposure			35	?
– Number of family members			101	?
– Student residency (+ denotes residents of university dorms are more active, - denotes students living in other accommodation types are more active)		195	95, 181	?
– Hometown (urban/rural)			92	?
– Campus/working location*		163, 197	44, 112, 159, 194	??
– Having a dependant			81	?
– Years of working experience		172		+
– Working position			112, 172, 197	?
– Working type			197	?
– Duration of health club membership			117	?
– Having a ‘dream job’		92		+
– Extra job (+ denotes yes, - denotes no)			112	?
– Ever attended a workshop on exercise (+ denotes yes, - denotes no)		124		+
Biological factors				
– Body mass index (BMI)	179	180	58, 109, 181, 197	??
– Underweight		131 (F), 150	131 (M)	+
– Overweight	150		65 (M, F), 114, 131 (M, F), 146 (M, F)	??
– Obesity	46 (M, F), 47 (M, F), 86, 114, 150		65 (M, F), 128, 131 (M, F)	??
– Waist circumference			197	?
– Body fat (%)			109	?
– Bone mineral density (BMD)		134, 138, 160 (M, F)	74, 90, 145	?
– Calcaneal stiffness index		160 (M, F)	160 (M, F)	?
– Skeletal muscle mass percent			143	?
– Dietary calcium intake		138		+
– Adequate serum vitamin D levels			143	?
– Sunlight exposure		138		+
– Total cholesterol (TCH) level			60 (M, F), 107	?
– Triglycerides (TG) level	60 (M, F), 107			-
– HDL-cholesterol level		60 (M, F), 107		+
– LDL-cholesterol level			107	?
– Total cholesterol: HDL-C ratio	60 (M, F)			-
– High TCH			60 (M, F)	?
– High TG	60 (M, F)			-
– Low HDL-C			60 (M, F)	?
– High TCH: HDL-C ratio			60 (M, F)	?

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Resting heart rate	107, 166 (M, F)			-
– Mean heart rate			166 (M, F)	?
– Predicted maximum heart rate (%)			166 (M, F)	?
– Systolic blood pressure			107, 166 (M, F)	?
– Diastolic blood pressure			107, 166 (M, F)	?
– Fasting plasma glucose			107	?
– VO_2max		166 (M, F)		+
– FEV1 (Abnormal lung function)			166 (M, F)	?
– FVC (Pulmonary function test)			166 (M, F)	?
– FEV1/FVC (%)			166 (M, F)	?
– Hematocrit level	73			-
– Hypercholesterolemia			103 (M, F)	?
Physical health				
– History of sickness/Underlying illness/Co-morbid diseases (+ denotes yes, - denotes no)			59, 101, 112, 181, 195, 197	??
– Hypertension			69	?
– Metabolic syndrome			136 (M, F)	?
– Osteoporosis		138		+
– Musculoskeletal symptoms	63, 144		85, 89, 133	?
– Relative appendicular skeletal muscle mass (RASM)		105 (F)	105 (M)	?
– Dysmenorrhea			57 (F)	?
– Age-related macular degeneration (AMD)	88			-
General health				
– Self-rated general health		87, 94, 175, 194, 197	159	++
Psychological factors				
– Mental health		32, 94, 175, 190		++
– Attitudes towards PA/exercise		49, 50 (M, F), 117, 154, 165, 186, 188, 190, 197	44, 70, 82, 112	++
– Overall health belief		170		+
– Self-efficacy		81, 83, 87, 140, 159, 172, 187, 194	72, 101, 137	++
– Perceived benefits of PA/exercise		50 (M, F), 83, 87, 101, 137, 172, 175, 194	59, 72, 159, 170, 187	++
– Perceived barriers for PA/exercise	72, 83, 87, 159, 170, 172, 176, 194		62, 101, 187	--
– Outcome expectancies		81, 140		+
– Intention to PA/exercise		140, 179		+
– Enjoyment of PA/exercise		59		+
– Perceived exercise-related effect	140		72, 170	?
– Career satisfaction		182		+

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Motivation for PA/exercise		83	76, 195	?
– External regulation			76	?
– Extrinsic motivation	76			-
– Intrinsic motivation		76		+
– Commitment to PA/exercise			151	?
– Stress level	179			-
– Sense of coherence			108	?
– Identity achievement			108	?
– Score on memory and intelligence tests			32	?
Physical skills, abilities, and fitness				
– Physical and functional fitness (e.g. walking distance, leg strength)		94, 166 (M, F)		+
Health behavioural and lifestyle factors				
– Smoking			78 (M, F), 153	?
– Alcohol consumption		177 (M)	177 (F)	?
– Healthy dietary habits		119		+
– Past PA/exercise experience		72		+
– Being a university athlete			137, 165	?
– Availability and/or engagement in enjoyable sports		115, 137		+
– Loving watching sports			115	?
– Having a favourite athlete			115	?
– Sedentary time	58		127	?
– Spare time		49, 59, 82, 115		++
– Monosodium glutamate (MSG) intake			71	?
Knowledge				
– Knowledge about PA/exercise	154	44, 50 (M, F), 59, 101, 117, 188, 194	49, 82, 87, 112, 159, 165, 195, 197	??
Academic/school performance				
– Grade point average			179	?
Social environment				
Social and cultural factors				
– Social support		50 (M, F), 87, 154, 159, 165, 180, 194, 197	101	++
– Cultural support		180		+
– General interpersonal influences	151	49, 82, 154, 187, 197	117	++
– Parent/family influences		81, 83, 137, 172	72, 117	++
– Family members' involvement in PA/exercise		137		+
– Friendship/companionship influences		81		+

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Friends' involvement in PA/exercise			115	?
– Information support (e.g. from media)		49, 154, 159, 194, 197	82	++
– Religion (+ denotes Buddhists are more active, - denotes Muslims are more active)		184	95	?
Physical environment				
Environmental factors				
– Environmental support (e.g. situational influences)		137	72, 151, 195	?
– Supportive physical environment (e.g. facilities, supplies)		81, 82, 87, 154	49, 101, 197	?
– Supportive neighbourhood environment			81	?
– Urban environment	35, 100 (M, F)			-
– Distance to work			58	?
– Distance to the nearest shopping place	58			-
– Distance to the nearest recreation facility			58	?
– Distance to the nearest religious establishment			58	?
– Convenience of travel			115	?
– Month of the year (+ denotes higher PA in later months of a calendar year)		109		+
Policy				
Policy attributes				
– Supportive education policies		82, 154, 165	49	+
– Supportive workplace policies			197	?

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female, Faculty* and Campus/working location* variables - due to a number of categories of these variables, we used only + (to denote any significant association of specific faculties or campuses/working locations) and ? (to denote a non-significant association) codes.

Correlates of older adults' physical activity

A total of 89 potential correlates of PA were studied in Thai older adults (Table 6.4). Consistent evidence of association with higher PA was found for the following individual-level factors: higher self-rated general health, better mental health, positive attitudes towards PA/exercise, higher self-efficacy, higher perceived benefits of PA/exercise, lower perceived barriers for PA/exercise, higher outcome expectancies, greater knowledge of PA/exercise, and better physical and functional fitness. No consistent evidence was found for social, environmental, and policy correlates of PA.

Some evidence of association with higher PA was found for the following individual-level factors: being a senior-citizen club member, being a Buddhist (when compared with being a Muslim), not being obese, lower triglyceride (TG), lower total cholesterol: HDL-C ratio, less likely to have high TG, lower resting heart rate, higher bone mineral density (BMD), higher HDL-cholesterol, higher VO_2max, better health-related quality of life, ever attended a workshop on exercise, higher dietary calcium intake, higher sunlight exposure, better saliva flow rate, less daily duty, lower hematocrit level, less likely to have abnormal symptoms, not having osteoporosis, not having age-related macular degeneration, not having periodontal disease, not perceiving exercise-related effect, lower score on Timed Up and Go test, lower sedentary time, greater perceived control, higher subjective norms, higher life satisfaction, higher career satisfaction, commitment to a plan of exercise, ability to do daily activities, greater enjoyment of PA/exercise, more spare time, better oral-health behaviours, and greater intention to PA/exercise. Some evidence supported associations between higher PA and the following social factors: greater friendship/companionship influences, better hospital staff support, and better information support. Some evidence supported associations between higher PA and the following environmental factors: better physical environment, better supportive neighbourhood environment, a sense of community, less exposure to urban environment, living in a residential community, and shorter distance to shopping place. No evidence was found for policy correlates of PA.

The associations between PA and age, sex, marital status, education level, and household income were mostly non-significant or largely inconsistent.

Table 6. 4 Summary of evidence on physical activity (PA) correlates in Thai older adults (60 years old and above)

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age	104, 139, 164, 191, 192	37, 58, 59, 124, 140	58, 66, 116, 117, 142, 155, 162, 174, 177, 185	??
– Sex (+ denotes males are more active, - denotes females are more active)	66, 100, 155	31, 42, 100, 116, 117, 142, 152, 162, 174, 184, 185	39, 58, 59, 68, 124, 139, 140, 164, 176, 191	??
– Municipality (+ denotes more PA in an urban place of residence, - denotes more PA in a rural place of residence)	58	192	58	?
– Marital status (+ denotes singles are more active)		66, 155	58, 59, 117, 139, 164, 174, 185, 191	??

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Education level	58, 116, 117	40, 59, 139, 142, 155, 162, 164, 185, 192	39, 58, 66, 174, 191	??
– Household income	66, 117	39, 40, 58, 139, 185, 192	58, 59, 142, 162	??
– Occupation (+ denotes unemployed are more active)		155	58, 59, 117	?
– Region (+ denotes Central including Bangkok residents are more active, - denotes residents of other provinces are more active)	134	155		?
– Daily duties (+ denotes individuals performing daily duties regularly are more active, - denotes individuals performing daily duties occasionally are more active)	162			-
– Senior-citizen club membership (+ denotes yes, - denotes no)		139, 191	66	+
– Duration of health club membership			117	?
– Ever attended a workshop on exercise (+ denotes yes, - denotes no)		124		+
Biological factors				
– Body mass index (BMI)			58, 66	?
– Overweight			147 (M, F)	?
– Obesity	47 (M, F)			-
– Bone mineral density (BMD)	42 (F)	99, 134, 138	42 (M)	+
– Skeletal muscle mass (%)			143	?
– Dietary calcium intake		138		+
– Adequate serum vitamin D levels			143	?
– Sunlight exposure		138		+
– Total cholesterol (TCH) level			60 (M, F)	?
– Triglycerides (TG) level	60 (M, F)			-
– HDL-cholesterol level		60 (M, F)		+
– Total cholesterol: HDL-C ratio	60 (M, F)			-
– High TCH			60 (M, F)	?
– High TG	60 (M, F)			-
– Low HDL-C			60 (M, F)	?
– High TCH: HDL-C ratio			60 (M, F)	?
– Resting heart rate	166 (M, F)			-
– Mean heart rate			166 (M, F)	?
– Predicted maximum heart rate (%)			166 (M, F)	?
– Systolic blood pressure	161		166 (M, F)	?
– Diastolic blood pressure	161		166 (M, F)	?
– VO_2max		166 (M, F)		+
– FEV1 (Abnormal lung function)			166 (M, F)	?

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– FVC (Pulmonary function test)			166 (M, F)	?
– FEV1/FVC (%)			166 (M, F)	?
– Hematocrit level	73			-
– Hypercholesterolemia			103 (M, F)	?
Physical health				
– History of sickness/Underlying illness/Co-morbid diseases (+ denotes yes, - denotes no)	66		59, 162	?
– Having health symptoms (i.e. fatigue, weight loss, sleep disorders) (+ denotes yes, - denotes no)	162			-
– Osteoporosis	138			-
– Age-related macular degeneration (AMD)	88			-
General health				
– Self-rated general health		98, 139, 164, 169, 175	192, 185	++
– Health-related quality of life		41, 48, 56		+
– General oral-health status (e.g. number of teeth, and oral malodour)			152	?
– Periodontal disease	152			-
– Saliva flow rate		152		+
Psychological factors				
– Mental health		32, 43, 98, 175	43	++
– Attitudes towards PA/exercise		79, 117, 188, 191		++
– Self-efficacy		79, 98, 104, 139, 140, 162, 185	39, 53, 174	++
– Perceived benefits of PA/exercise		40, 79, 139, 174, 177, 192	39, 59	++
– Perceived barriers for PA/exercise	39, 40, 79, 139, 176		53, 174	--
– Outcome expectancies		79, 104, 140, 162		++
– Intention to PA/exercise		79, 140		+
– Perceived control		79		+
– Subjective norms		79		+
– Enjoyment of PA/exercise			59	+
– Perceived health risks of exercise	140			-
– Life satisfaction		120		+
– Career satisfaction		182		+
– Motivation for PA/exercise			174	?
– Score on memory and intelligence tests			32	?
– Commitment to an exercise plan		53		+
Physical skills, abilities, and fitness				
– Ability to do daily activities		192		+

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Physical and functional fitness (e.g. walking distance, leg strength)		43, 34, 93, 166 (M, F)		++
– Score on Timed Up and Go test	93			-
Health behavioural and lifestyle factors				
– Smoking	66		78 (M, F), 153	?
– Alcohol consumption	66	177 (M)	177 (F)	?
– Sedentary time	58			-
– Spare time		59		+
– Oral-health behaviours (i.e. tooth brushing, and regular dental visits)		152		+
Knowledge				
– Knowledge about PA/exercise		59, 117, 188, 191	162	++
Social environment				
Social and cultural factors				
– Social support		53, 192	98, 162, 174	?
– General interpersonal influences		139	117	?
– Parent/family influences		191, 192	39, 104	?
– Friendship/companionship influences		191, 192	104	+
– Hospital staff support		191		+
– Information support (e.g. from media)		164		+
– Religion (+ denotes Buddhists are more active, - denotes Muslims are more active)		184, 192		+
Physical environment				
Environmental factors				
– Supportive physical environment (e.g. facilities, supplies)		39, 192	117	+
– Supportive neighbourhood environment		39, 40, 104	98	+
– A sense of community		98		+
– Urban environment	100 (M, F)			-
– Residential community (+ denotes rural community is more active, - denotes residential home is more active)		68		+
– Distance to work			58	?
– Distance to the nearest shopping place	58			-
– Distance to the nearest recreation facility			58	?
– Distance to the nearest religious establishment			58	?

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

Sedentary behaviour correlates

The included studies reported associations with SB for a total of 41 variables [33, 43, 46, 47, 54, 58, 61, 67, 71, 75, 84-86, 89, 91, 96, 100, 102, 105, 106, 111, 118, 125, 126, 128, 129, 131, 133, 135, 141, 147-149, 156, 157, 169, 171, 173, 177, 178]. More than half of them were significantly associated with SB (53.7%; *n* = 22). In older adults, the included studies investigated only potential SB correlates at the individual level, while they also examined social factors in children and adolescents, and in adults, also environmental factors.

Correlates of children' and adolescents' sedentary behaviour

A total of 19 potential correlates of SB were studied in Thai children and adolescents (Table 6.5). Some evidence of association with higher SB was found for older age/higher school grade, higher body weight, higher BMI, more physical pain, less participation in sports, more time spent with family, and more participation in extracurricular activities. Non-significant associations with SB were consistently found for sex, being overweight, and obesity.

Table 6. 5 Summary of evidence on sedentary behaviour (SB) correlates in Thai children and adolescents (6 – 17 years old)

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age/School grade		118, 147	91	+
– Sex (+ denotes higher SB in males, - denotes higher SB in females)	147	67, 75, 91, 111, 118, 141	67, 91, 111, 118, 126, 135	??
– Household income		96	75	?
– Parents' marital status			75	?
– Parents' education level			91	?
– Municipality (+ denotes higher SB in an urban place of residence, - denotes higher SB in a rural place of residence)	135 (M)	106	67, 106, 135 (F)	?
Biological factors				
– Body weight		61		+
– Body mass index (BMI)		147		+
– Overweight		111 (F), 171, 157	111 (M, F), 125 (F), 157	??
– Obesity		47 (M, F), 130 (M), 148, 156, 157, 169	33, 96 (F), 130 (F), 157, 173	??
Physical health				
– Asthma			157	?
– Hypertension		157	157	?

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	**Positive (+)**	**Non-significant (?)**	
– Physical pain		61		+
Health behavioural and lifestyle factors				
– Physical activity participation			178	?
– Playing sports	61			-
Academic/school performance				
– Grade point average	54, 75, 91	61	91, 157	?
Social environment *Social and cultural factors*				
– Time spent with family		61		+
– Good relationship with friends			61	?
– Participation in extracurricular activities		61		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

Correlates of adults' sedentary behaviour

In total, 17 potential correlates of SB were studied in Thai adults (Table 6.6). A consistent association with SB was found for obesity. Some evidence of association with higher SB was found for being a male, higher education level, low back pain, higher alcohol consumption, lower grade point average, more musculoskeletal symptoms, heavy Internet use, less transport PA, less recreation PA, and more exposure to an urban environment.

Table 6. 6 Summary of evidence on sedentary behaviour (SB) correlates in Thai adults (18 – 59 years old)

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level *Demographic factors*				
– Age		102	84	?
– Sex (+ denotes higher SB in males, - denotes higher SB in females)	84	75, 102, 141		+
– Household income		149	75	?
– Parents' marital status			75	?
– Education level		102		+
Biological factors				
– Underweight			131 (M, F)	?
– Overweight			131 (M, F)	?
– Obesity		46 (M, F), 47 (M, F), 86	46 (M), 131 (M, F)	++

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Physical health				
– Musculoskeletal symptoms		85		+
– Low back pain		89, 133 (F)	89	+
– Relative skeletal muscle mass of limbs	105 (F)		105 (M)	?
Health behavioural and lifestyle				
– Having transport and recreation physical activity	58			-
– Heavy internet use		127		+
– Monosodium glutamate (MSG) intake			71	?
– Alcohol consumption		177 (M, F)		+
Academic/school performance				
– Grade point average	75, 84, 149			-
Physical environment				
Environmental factors				
– Urban environment		100		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

Correlates of older adults' sedentary behaviour

Only five potential correlates of SB were studied in Thai older adults (Table 6.7). No consistent evidence from multiple studies was found on SB correlates in this age group. Some evidence of an association with higher SB was found for obesity, higher alcohol consumption, worse mental health, less active transport, and less recreational PA.

Table 6. 7 Summary of evidence on sedentary behaviour (SB) correlates in Thai older adults (60 years old and above)

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Psychological factors				
– Mental health	43			-
Biological factors				
– Obesity		47 (M, F)		+
Physical skills, abilities, and fitness				
– Functional fitness	43		43	?
Health behavioural and lifestyle factors				
– Engaging in transport and recreation physical activity	58			-

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Alcohol consumption		177 (M, F)		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

Discussion

Physical activity correlates

A range of factors potentially associated with PA levels in the Thai population were identified at the individual, social, environmental, and policy levels. However, consistent evidence of association with PA was found only for individual-level and social correlates in children/adolescents and adults and for individual-level correlates in older adults. The summary findings suggest that PA promotion strategies in Thailand need to address several intrapersonal and interpersonal factors and may need to be tailored specifically for different age groups. The lack of consistent evidence from multiple studies for environmental and policy correlates may partially be explained by the fact that most of the included studies assessed individual-level and social correlates only. Future research should, therefore, place more focus on examining potential environmental and policy correlates of PA in the Thai population. Our findings also suggest that correlates of PA in Thailand may be different than in some other countries, calling for more focused, individual-country reviews of this kind.

In the current review, we found consistent evidence for the associations of younger age and male sex with higher PA only in children and adolescents. Among Thai adults and older adults these associations were inconsistent. A previous review for low- and middle-income countries [2] reported “mixed or weak” associations of gender and age with PA, whilst reviews for high-income countries [9, 23, 25] reported consistent associations. This might suggest that socioeconomic context in a given country may play a role in shaping the relationships of age and gender with PA. This should be further explored in future reviews of PA correlates in low- and middle-income countries and individual studies on gender- and age-specific determinants of PA. Given a relatively large number of studies included in the current review examining the association of PA with age and sex, the lack of consistent evidence in adults and older adults may suggest that the situation in Thailand is indeed different than in some other countries. For most other demographic variables, evidence on their association with PA was scarce or inconsistent in all age groups. More research is needed to understand which demographic characteristics are associated with higher PA levels in Thailand.

Evidence has strongly supported associations between different aspects of health and PA regardless of age [1, 198-201]. Whilst we found evidence on the association of PA with self-reported general health in all age groups and with mental health in adults and older adults, evidence for most other, specific health variables and biological factors was scarce or inconsistent. Moreover, it should be noted that some of the identified health-related variables associated with PA may be outcomes of PA rather than factors affecting PA [202]. For example, it may be that in Thai adults high PA improves general health status, whilst it may also be that healthier Thai adults are more likely to engage in PA. The causality might as well be bidirectional [202]. From the cross-sectional studies included in this review, it was not possible to conclude about the causal direction of the relationships. Clearly, more research is needed on biological and health-related correlates of PA in the Thai population. Furthermore, a large proportion of non-significant associations found between obesity and PA in Thai adults is in accordance with findings of most previous, non-country-specific reviews [6]. Although it may seem reasonable to assume that obese people are less likely to engage in PA, and that more physically active people are less likely to get obese, this association is clearly not so straightforward. Multiple other factors, particularly diet, need to be considered to understand the potential association between PA and obesity.

Previous reviews have identified physical skills, abilities, and fitness as important correlates of PA in all age groups [25, 203, 204]. Based on our review, it seems that this is also the case in the Thai context. It should be noted, however, that findings for nearly every variable in this category are based on results from only one study. Furthermore, findings for behavioural and lifestyle correlates of PA were mixed. We found evidence suggesting that higher PA is associated with past PA/exercise experience in children/adolescents and adults and knowledge of PA/exercise in children and older adults. Providing exercise instructions and opportunities to gain experience in PA/exercise might, therefore, be an effective way to increase PA participation in the Thai population. We also found that having more spare time may be associated with higher PA in adults and older adults. Time management interventions aimed at achieving balanced time use, to ensure enough spare time is available for engaging in PA, may be needed to increase PA levels in the Thai population [7].

It is interesting that consistent evidence of association with PA across all three age groups was found only for two psychological factors; namely self-efficacy and perceived barriers. Our finding regarding self-efficacy is in accordance with previous studies that identified this characteristic as an important determinant of PA behaviour across lifespan; from childhood to older age [2, 9, 25, 205, 206]. Furthermore, perceived barriers for PA are one’s evaluations of potential obstacles to start engaging in PA and/or to maintain regular PA (e.g. time constraints, lack of skills, unsuitable weather conditions). Although barriers for PA/exercise may be perceived differently by members of different age groups [207], they seem to be consistently negatively associated with PA behaviour for people of all ages in the Thai population. In previous, multinational reviews, including studies conducted in low-, middle-, and high-income countries, the authors reached inconsistent conclusions with respect to barriers to PA/exercise [2, 9, 24, 25]. For example, whilst Sallis et al. [24] suggested that perceived barriers are significantly associated with PA in children, van der Horst et al. suggested they are not [208]. Similarly, inconclusive findings for adults and older adults have also been reported by other authors [2, 25]. It may be that the association between perceived barriers to PA and PA levels is country-specific. Thus, acquiring country-level evidence may be needed to design effective interventions to tackle perceived barriers to PA.

Social support (e.g. from parents, family, and friends) was identified as a motivator for increased participation in PA, especially for Thai children/adolescents and adults. This is in accordance with findings of previous reviews [2, 9, 24, 209-211]. Interestingly, friend or peer influences have been shown to have a significant direct effect on PA among adolescents, while parents seem to have a more indirect influence [212]. In the current review, we found evidence suggesting that influences from both friends and parents may play important roles in children's/adolescents' engagement in PA. Several studies included in the present review also suggested that parental or family influences may be important correlates of PA in Thai adults. Although only one study showed a positive correlation between friendship/companionship influences and PA in this age group, the evidence should not be ignored, as this was a relatively large study [74]. Social support from friends and companions seem to be an enabler of PA also in Thai older adults. In this age group, support from hospital staff to engage in PA may be important. Therefore, improving different aspects of social support need to be taken into consideration when designing PA strategies and interventions for the Thai population.

Worldwide, a range of environmental attributes have been associated with PA, such as community resources, neighbourhood safety, transportation environment, access to sport and exercise facilities, routine destinations in daily life, and accessibility of public green spaces [2, 9, 18, 24, 25, 209-211, 213-217]. Interestingly, access and proximity to facilities appear to be important contributors to youth PA regardless of country's economic status [2, 9, 24, 209, 210, 217]. Evidence on the associations between most aspects of physical environment and PA in Thai adults is inconclusive. This is mainly because of the limited number of studies conducted on this topic. Some evidence suggests that PA of children/adolescents and older adults in Thailand may be associated with neighbourhood design, which is consistent with findings from other, non-country specific reviews [218, 219]. Given the plethora of evidence from other countries and some evidence from Thailand, it seems important to improve features of the physical environment to increase PA participation in the Thai population. Nevertheless, more studies are needed to investigate environmental correlates of PA that are specific for Thailand.

In terms of policy-related correlates of PA, very few variables have been investigated. Only five studies have examined the effects of policies on PA in Thailand and were carried out at the local level (i.e. the school and workplace) and among adults [31, 74, 80, 90, 94]. Some evidence suggests that education policies (in specific, university policies) may be associated with PA, whilst a single study did not find a significant association between workplace policies and PA. Further investigations on the potential impact of policies on PA is encouraged.

Sedentary behaviour correlates

A limited number of studies have examined correlates of SB in Thai populations, especially in older adults. Some evidence suggests that, among Thai adults, males engage more in SB than females. This is in accordance with the associations between overall SB and sex found in several other countries [20]. Furthermore, consistent evidence from multiple studies was found for the association between obesity and SB in Thai adults. An umbrella review has suggested that available evidence is not supportive of this association in adults [220]. It might, therefore, be that the findings of the current review reflect only a context-specific situation in Thailand. Based on the available evidence, it seems that interventions for reducing SB should particularly focus on obese individuals, as being obese seems to be associated with more SB. It should be noted, however, that all Thai studies supporting this association are cross-sectional; hence, no inferences can be made about the direction of the relationship. Nevertheless, a previous longitudinal study suggested that obesity may lead to a subsequent increase in SB, whilst there was no evidence for the association in the other direction [221]. Besides, we found mostly non-significant associations between being overweight and engaging in SB. It might, therefore, be that only more severe issues with excessive weight lead to increases in SB. We also found some evidence supporting the association between SB and musculoskeletal disorders. Experiencing bodily pain was associated with higher SB in children and adolescents, whilst having musculoskeletal symptoms and low back pain were associated with higher SB in adults. These findings must be taken with caution, because previous longitudinal studies provided very little evidence in support of such associations [6, 222]. Furthermore, alcohol consumption was found to be associated with increased SB in both adults and older adults. These are, however, findings from one study only (examining both age groups) and given the inconsistent evidence for this association found in a previous review [20], this warrants further investigation. Associations of other variables and SB were either non-significant or supported by a single study, which demonstrates the need for more studies on SB in Thai populations, and particularly in older adults.

Strengths and limitations

This systematic review has several strengths. Most previous reviews of PA/SB correlates did not present country-specific findings. In the current review, for the first time, findings on potential PA/SB correlates in the Thai population were extracted and summarised from many original studies (*n* = 167). Previous reviews on PA/SB correlates have cited primarily research published in the English language, which may have introduced bias into their findings. In this review, we included publications in both Thai and English; the languages that Thai researchers predominantly use in academic communication. Furthermore, we examined numerous potential correlates, particularly for PA, at all levels—individual, social, environmental, and policy. This comprehensive approach enabled us to better elucidate the complexity of PA and SB behaviours in the Thai population.

This review was not without limitations. Firstly, we did not use a formal meta-analytical procedure to combine the results of individual studies. Given the large number of analysed correlates and great heterogeneity between studies in terms of measures of PA/SB and statistical methods they used, we opted for the procedure for summarising results of individual studies proposed by Sallis et al. [24]. This procedure has been used in several previous systematic reviews in the field of public health. Secondly, relying on evidence from cross-sectional studies has prevented us from drawing conclusions about the direction of the summarised relationships. This was inevitable, because we did not identify any longitudinal studies on factors affecting PA/SB in Thailand. Finally, the findings of this review may have been influenced by recall errors, because the clear majority of included studies relied on self-reported PA/SB, and only a few used devices to assess these behaviours.

Recommendations for future research

A limited number of studies examined SB correlates, particularly for older adults. More research is needed to understand why Thais engage in excessive SB and which factors to address to prevent it. Furthermore, less than one-fourth of all studies on PA correlates were conducted among children and adolescents. These age groups should, therefore, be designated as a priority target for future research on PA correlates. For most correlates of both PA and SB, only few findings from individual studies are available. This is particularly the case for social, environmental, and policy-related variables. More research is needed on most potential correlates of PA and SB in the Thai population. Another challenge stems from the fact that all studies included in this review used cross-sectional designs. To provide evidence on prospective and causal relationships between the variables and PA/SB, longitudinal and intervention studies should be conducted. In addition, to improve the validity of PA/SB estimates and avoid the potential recall bias, subject to feasibility, researchers are encouraged to employ devices, such as accelerometers, pedometers, or multi-sensor measures.

Conclusions

This review is one of the first to summarise within-country correlates of PA and SB across population groups. Given a range of differences between the findings of the current review and the findings of previous non-country specific reviews, it may be important to consider correlates of PA and SB at the country-level. This may be particularly relevant when such reviews are completed to inform national- and local-level public health interventions.

Findings of the current review suggest that several factors are associated with PA levels in the Thai population. Based on the available evidence, to increase PA in Thailand, public health interventions should focus on helping individuals: improve self-efficacy; circumvent perceived barriers for PA; improve general and mental health; find enough spare time to engage in PA; improve physical skills, abilities, and fitness; gain knowledge about and experience in exercise; and receive adequate social support for participation in PA. Furthermore, the body of literature on correlates of SB in Thailand is limited. Nevertheless, evidence suggests that interventions for reducing SB in Thai adults should primarily target obese individuals, as they seem to be at a greater risk of high SB.

More Thai studies are needed on PA correlates, particularly among children and adolescent and with a focus on environment- and policy-related factors. Much greater commitment is needed to investigating correlates of SB in Thailand, particularly among older adults. The Thai Government and public health stakeholders should provide a systematic support to such research, as it provides knowledge that is crucial for designing public health policies, strategies, and interventions.

List of abbreviations

- Moderate Physical Activity (MPA)
- Moderate-to-Vigorous Physical Activity (MVPA)
- Networked Digital Library of Theses and Dissertations (NDLTD)
- Physical Activity (PA)
- Sedentary Behaviour (SB)

- Television (TV)
- Vigorous Physical Activity (VPA)
- World Health Organization (WHO)

Declarations

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Availability of data and materials

The summary of reviewed articles is available in Tables, Figures, and Supplementary materials

Authors' contributions

NL and ZP conceived the idea for the review. NL, ZP, MC, and SJHB conceptualised the review. NL led the writing of the study protocol. NL and ZP designed the strategies for a systematic search. NL and KS conducted the study selection. NL extracted the data, assessed the quality of the studies, and analysed the data. NL drafted the initial manuscript. ZP, MC, SJHB, and KS contributed to writing the manuscript. All authors read and approved the final draft.

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Competing interests

The authors declare no competing interests.

Consent for publication

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Ethics approval and consent to participate

Not applicable

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Additional Files

Additional File 1

File name: Additional file 1_full data extraction table.xlsx

Title: Data Extraction Table

Description: The detailed table of all data extracted from each study included

Additional File 2

File name: Additional file 2_supplementary correlate tables.pdf

Title: Supplementary Correlate Tables

Description: The additional tables of correlates for individual type of physical activity

Additional File 3

File name: Additional file 3_NOS quality score table.pdf

Title: Results of the study quality assessment using the Newcastle-Ottawa Scale for cross-sectional studies

Description: The quality assessment score for included studies assessed by Newcastle-Ottawa Scale (NOS)

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CHAPTER VII: Standardised criteria for classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity

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GRADUATE RESEARCH CENTRE

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This declaration is to be completed for each conjointly authored publication and placed at the beginning of the thesis chapter in which the publication appears.

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2. CANDIDATE DECLARATION

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;
2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. There are no other authors of the publication according to these criteria;
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Standardised criteria for classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity

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Abstract

Background

Globally, the International Classification of Activities for Time-Use Statistics (ICATUS) is one of the most widely used time-use classifications to identify time spent in various activities. Comprehensive 24-hour activities that can be extracted from ICATUS provide possible implications for the use of time-use data in relation to activity-health associations; however, these activities are not classified in a way that makes such analysis feasible. This study, therefore, aimed to develop criteria for classifying ICATUS activities into sleep, sedentary behaviour (SB), light physical activity (LPA), and moderate-to-vigorous physical activity (MVPA), based on expert assessment.

Method

We classified activities from the Trial ICATUS 2005 and final ICATUS 2016. One author assigned METs and codes for wakefulness status and posture, to all subclass activities in the Trial ICATUS 2005. Once coded, one author matched the most detailed level of activities from the ICATUS 2016 with the corresponding activities in the Trial ICATUS 2005, where applicable. The assessment and harmonisation of each ICATUS activity were reviewed independently and anonymously by four experts, as part of a Delphi process. Given a large number of ICATUS activities, four separate Delphi panels were formed for this purpose. A series of Delphi survey rounds were repeated until a consensus among all experts was reached.

Results

Consensus about harmonisation and classification of ICATUS activities was reached by the third round of the Delphi survey in all four panels. A total of 542 activities were classified into sleep, SB, LPA, and MVPA categories. Of these, 390 activities were from the Trial ICATUS 2005 and 152 activities were from the final ICATUS 2016. The majority of ICATUS 2016 activities were harmonised into the ICATUS activity groups (*n* = 143).

Conclusions

Based on expert consensus, we developed a classification system that enables ICATUS-based time-use data to be classified into sleep, SB, LPA, and MVPA categories. Adoption and consistent use of this classification system will facilitate standardisation of time-use data processing for the purpose of sleep, SB and physical activity research, and improve between-study comparability. Future studies should test the applicability of the classification system by applying it to empirical data.

Keywords

ICATUS, Time-use survey, Physical Activity, Sedentary Behaviour, Sleep, Time-use epidemiology

Background

Sleep, sedentary behaviour (SB), light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA) are activity-based behaviours associated with a range of health outcomes (Grgic et al., 2018). For example, short duration of sleep is associated with a higher risk of developing coronary heart disease, stroke, type II diabetes, and certain types of cancer (Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011; Cappuccio, D'elia, Strazzullo, & Miller, 2010; Zhao et al., 2013). It is suggested that too much SB increases the risk of cardiovascular disease, type II diabetes, and metabolic syndrome (de Rezende, Lopes, Rey-Lopez, Matsudo, & do Carmo Luiz, 2014). Physical inactivity (usually defined as insufficient amount of MVPA to meet physical activity (PA) recommendations (Mark S. Tremblay et al., 2017)) is also associated with an increased burden of disease, including coronary heart disease, type II diabetes, breast cancer, and colon cancer (Lee et al., 2012). Although previous studies examined sleep, SB, LPA, and MVPA as independent predictors of health outcomes, recently, methodological papers suggest these are all mutually exclusive and exhaustive components of the time-finite 24-hour day, and should, therefore, be considered as co-dependent variables

(Dumuid, Stanford, Martin-Fernández, et al., 2018; Pedišić, 2014; Pedišić, Dumuid, & S Olds, 2017). Recent studies aimed to acknowledge co-dependence of these variables using different analytical approaches, such as isotemporal substitution and compositional data analysis (Chaput, Saunders, & Carson, 2017; Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015; Dumuid et al., 2019; Dumuid, Stanford, Martin-Fernández, et al., 2018; Fishman et al., 2016; Grgic et al., 2018; Charles E Matthews et al., 2016; Mekary, Willett, Hu, & Ding, 2009; Stamatakis et al., 2015). Despite the differences in statistical approaches, there is wide agreement that conceptualising and studying sleep, SB, and PA as integral parts of the 24-hour day may lead to novel and important insights into activity-based behaviours and health (Dumuid, Stanford, Martin-Fernández, et al., 2018; Matricciani et al., 2018; Pedišić et al., 2017; Rosenberger et al., 2019; Tremblay et al., 2016; World Health Organization, 2019). This new way of conceptualising activity-based behaviours is sometimes referred to as the "Time-Use Epidemiology" paradigm (Pedišić et al., 2017).

National time-use surveys have been conducted in over 85 countries worldwide (United Nations Statistics Division, 2018). Time-use survey data have been of great interest for researchers, due to their comprehensiveness and a broad range of possible applications in public health, sociology, economics, and transportation research (Deyaert, Harms, Weenas, Gershuny, & Glorieux, 2017). It is widely accepted that the validity and reliability of time-use survey data are adequate for large-scale, observational studies (Deyaert et al., 2017; Harvey & Pentland, 1999; Ridley, Olds, & Hill, 2006; Tudor-Locke, Ainsworth, Washington, & Troiano, 2011; Tudor-Locke, Leonardi, Johnson, & Katzmarzyk, 2011; Tudor-Locke, Washington, Ainsworth, & Troiano, 2009; van der Ploeg et al., 2010). Several studies used time-use data to investigate population-level PA patterns (Adams, 2010; Millward, Spinney, & Scott, 2013; J. E. Spinney, Scott, & Newbold, 2009; Tudor-Locke, Bittman, Merom, & Bauman, 2005; Tudor-Locke & Ham, 2008; Tudor-Locke et al., 2007; Turcotte, 2009).

Most previous studies in time-use epidemiology have relied on accelerometer-based estimates of sleep, SB, and PA (Biddle et al., 2018; Carson, Tremblay, & Chastin, 2017;

Chastin et al., 2015; Debache et al., 2019; Dumuid, Stanford, Pedišić, et al., 2018; Fairclough et al., 2017; Gupta et al., 2019; Pelclová et al., 2018; Talarico & Janssen, 2018; Taylor et al., 2019). While accelerometers have undoubtedly been providing useful data for time-use epidemiology, they have limitations in terms of validity, generalisability, between-study comparability, and comprehensiveness of movement behaviour estimates (Pedišić & Bauman, 2015). The affordability and sustainability of their use in population surveillance has also been questioned (Pedišić & Bauman, 2015). With complete 24-hour data, time-use surveys may be a good alternative to accelerometers, as they also allow researchers to investigate the combined effects of all movement-related behaviours on health (Bauman, Bittman, & Gershuny, 2019). They can also be used to track the prevalence of meeting the new integrative 24-hour movement guidelines that include joint recommendations for sleep, SB, and PA (New Zealand Ministry of Health, 2017; Okely et al., 2017; Tremblay et al., 2016; Mark S Tremblay et al., 2017; Weenas, van Tienoven, Verbeylen, Minnen, & Glorieux, 2019; World Health Organization, 2019). However, as time-use surveys were not designed specifically to collect data on PA and SB, their use in time-use epidemiology has been limited. The 24-hour movement behaviour data from time-use surveys are, therefore, yet to be explored in detail in relation to health outcomes. To enable this, classification systems for deriving health-related time-use compositions from time-use surveys must be developed and evaluated (Harms, Berrigan, & Gershuny, 2019; Charles E. Matthews et al., 2019; Ng & Popkin, 2012; Tudor-Locke et al., 2009). A recently developed framework entitled Viable Integrative Research in Time-Use Epidemiology (VIRTUE) recognised this as a methodological task of fundamental importance for the further development of time-use epidemiology (Pedišić et al., 2017). The availability of such classification systems is a prerequisite for utilisation of time-use survey data in epidemiological studies on movement-related behaviours.

Response options in time-use surveys are often derived from standardised time-use classification systems. The International Classification of Activities for Time-Use Statistics (ICATUS) is one of the most widely used time-use classification systems. It was developed by the United Nations Statistics Division (UNSD) to provide meaningful and comparable time-use statistics across countries and over time (Charmes, 2015; United Nations Statistics Division, 2017, 2018). ICATUS has been used as a framework for several nationally representative time-use surveys, mostly in Asia and Africa (Charmes, 2015). The ICATUS was first introduced as a draft classification in 1997 by the UNSD. In 2000, the expert group carried out further refinements to the activity categories, which was published in 2005 as the Trial ICATUS (United Nations Statistics Division, 2017). Several consultation meetings were organised between 2012 and 2016 among experts and relevant stakeholders to finalise the classification (United Nations Statistics Division, 2017). The ICATUS 2016 is the final version, with a simplified structure and terminologically aligned with existing international standards, such as the System of National Accounts and the International Standard Industrial Classification of All Economic Activities (United Nations Statistics Division, 2017). The Trial ICATUS 2005, a five-level hierarchical classification, is comprised of 15 major divisions, 54 divisions, 92 groups, 200 classes and 363 subclasses. The ICATUS 2016, a three-level hierarchical classification, includes 9 major divisions, 56 divisions, and 165 groups. The Trial ICATUS 2005 has been used in many national time-use surveys since 2000, while the ICATUS 2016 is a finalised classification system for future ICATUS-based time-use surveys (United Nations Statistics Division, 2017).

Activity categories from several time-use surveys have previously been classified according to their “Metabolic Equivalent of Task” (MET) (Chau et al., 2012; Espinel, Chau, van der Ploeg, & Merom, 2015; Millward & Spinney, 2011; J. E. Spinney, Millward, & Scott, 2011; Tudor-Locke et al., 2009; van der Ploeg et al., 2010; van Tienoven et al., 2018). One MET describes the human energy expenditure while at rest (i.e., resting metabolic rate or approximately 1 kcal/kg/hour), whilst two METs is twice that at rest (World Health Organization, 2012). Tudor-Locke and colleagues (2009) assigned MET values to 438 activities in the American Time Use Survey (ATUS) according to the 2011 Adult Compendium of Physical Activities (hereafter called “the Compendium”) (Ainsworth et al., 2011; Tudor-Locke, Ainsworth, et al., 2011; Tudor-

Locke, Leonardi, et al., 2011; Tudor-Locke et al., 2009). Several studies have also applied METs using the Compendium in other time-use surveys, such as the Australian Time Use Survey, Statistics Canada's General Social Survey – Time Use (GSS-TU), and Belgian Time Use Survey (using Harmonised European Time Use Survey [HETUS] classification) (Chau et al., 2012; Espinel et al., 2015; Millward, Spinney, & Scott, 2014; J. E. Spinney et al., 2011; van der Ploeg et al., 2010; van Tienoven et al., 2018). However, no previous studies have developed criteria for classifying ICATUS activities into sleep, SB, LPA, and MVPA categories.

Like other systems that can classify time-use components into different types of health-related domains (e.g. social activities, cognitive activities), a classification system for classifying the ICATUS activities into major activity-based time-use components (i.e., sleep, SB, LPA, and MVPA) would also enable time-use epidemiologists to process data from many existing and future population-representative surveys. Such a system would also facilitate standardisation of data processing in this area, which may improve between-study comparability. To be able to classify time-use components into sleep, SB, LPA and MVPA, one must know: (i) their MET value; (ii) whether they are done while awake or while asleep; and (iii) in which posture they are performed (Pedišić et al., 2017; Mark S. Tremblay et al., 2017). However, these three criteria have never been inclusively assigned to any time-use surveys. This study, therefore, aimed to assign MET values and codes for wakefulness status and posture to the Trial ICATUS 2005 and the Final ICATUS 2016 activities to enable their classification into sleep, SB, LPA, and MVPA categories. It can be expected that future studies will predominantly use the Final ICATUS 2016. Nevertheless, it should not be disregarded that the Trial ICATUS 2005 has already been used in many national time-use surveys for over a decade, which means a lot of valuable time-use data is already available. To facilitate comparability between studies based on the Trial ICATUS 2005 and the Final ICATUS 2016 and enable research on trends in movement-related behaviours (which are lacking for many countries), we decided to classify activities from both versions.

Methods

Classification criteria

Criteria used to classify time into sleep, SB, LPA, and MVPA were: 1) relative energy expenditure (MET values from the Compendium (Ainsworth et al., 2011)); 2) wakefulness (yes or no); and 3) sitting/reclining/lying posture (yes or no). The answer "no" to sitting/reclining/lying posture implied standing or being on one's feet while performing an activity. The ICATUS activities were classified into sleep, SB, LPA, and MVPA categories based on the criteria presented in Table 7.1. Given that a number of ICATUS activity categories are very broad and non-specific, in many cases it would not be possible to make a clear distinction between moderate and vigorous intensity. We, therefore, combined these two intensity levels into MVPA.

Table 7. 1 Criteria for classifying time-use components into sleep, SB, LPA, and MVPA

Activity-based category	METs	Wakefulness	Sitting/reclining/lying
Sleep	<1	No	Yes or No
SB	≥1 – ≤1.5	Yes	Yes
LPA	>1.5 – <3	Yes	Yes or No
MVPA	≥3	Yes	Yes or No

Notes: MET: metabolic equivalent of task; SB: sedentary behaviour; LPA: light physical activity; MVPA: moderate-to-vigorous physical activity

Initial assessment of ICATUS activities

The initial assessment of activities was done for the Trial ICATUS 2005, because the Trial ICATUS provides a more detailed classification activities than the Final ICATUS. The Trial ICATUS 2005 groups activities into five levels. The first level, 2-digit code or "major divisions" includes the broadest groups of activities, and the fifth level, 6-digit code or "subclasses" represents the most detailed level of the classification (Statistical Division United Nations, 2005). The major divisions and their associated subclass activities of the Trial ICATUS 2005 were entered into a separate Excel spreadsheet. One author (NL) conducted an initial assessment by assigning i) relative energy expenditure (MET values from the Compendium); ii) wakefulness status (yes or no); and 3) sitting/reclining/lying posture (yes or no) to each 6-digit activity in each major division of the Trial ICATUS 2005. When assigning the codes, NL consulted the Guide to Producing Statistics on Time Use which provided definitions and descriptions of ICATUS activities, including examples and exceptions (Statistical Division United Nations, 2005). To assign a MET value, each ICATUS subclass activity was matched with one or more Compendium activities according to the examples and descriptions provided in the above-mentioned documents. The coding rules presented in Table 7.2 were used in the assessment.

Table 7. 2 Coding rules to assign Compendium METs, wakefulness, and posture to the ICATUS activities

<table>
<tr><td>Coding rule 1</td><td colspan="3">Assign the codes and MET values from the Compendium and the codes for wakefulness and posture to each 6-digit activity</td></tr>
<tr><td rowspan="4">Coding rule 2</td><td rowspan="4">Use a median MET estimate of the respective activities or subcategories</td><td>2a.</td><td>when more than one activity from the Compendium was assigned to a 6-digit activity</td></tr>
<tr><td>2b.</td><td>when assigning METs to a 4-digit and 5-digit activity</td></tr>
<tr><td>2c.</td><td>when an activity is classified as “not further defined” (n.f.d.) or “not elsewhere classified” (n.e.c.)</td></tr>
<tr><td>2d.</td><td>when there is insufficient information in the explanatory notes; usually classified as “other related activities” and ends in “9”</td></tr>
<tr><td>Coding rule 3</td><td colspan="3">Assign the codes for summary wakefulness and posture to a 4-digit and 5-digit activity according to the assessments made for the majority of its 6-digit subclass activities</td></tr>
</table>

Notes: Compendium: 2011 Adult Compendium of Physical Activities (Ainsworth et al., 2011); MET: metabolic equivalent of task; ICATUS: International Classification of Activities for Time Use Statistics; n.f.d.: not further defined; n.e.c.: not elsewhere classified

The MET values and codes for wakefulness status and posture were assigned to the most detailed level of activities (i.e., subclass activities). For the activities that are broadly described and encompass more than one specific activity in the Compendium, a median MET value of respective Compendium activities was calculated. The summary MET values were also computed for the 4-digit and 5-digit activities in ICATUS 2005 as a median MET value assigned to their subclasses. Summary wakefulness and posture categories were assigned to each 4-digit and 5-digit activity according to the respective assessments made for the majority of its subclasses. The summary assessments were also used for an activity classified as "not further defined" (n.f.d.) or "not elsewhere classified" (n.e.c.) or "other related activities" or ends in "9" activities, where information is insufficient. An extract from the table used in the described assessment process is shown in Table 7.3, while the complete table can be found in Additional File 1.

Table 7. 3 An extract from the table used for the assessment of ICATUS 2005 activities

ICATUS 2005				**Assessment**			**Compendium of Physical Activities**		
Code			Description	Summary METs	Wakefulness (Yes/No)	Sitting/reclining/lying (Yes/No)	Code	Major heading: specific activities	METs
1211			**Visual, literary and performing arts (as hobby) and related courses**	**2.75 (median of four subclass activities)**	**yes**	**no**			
	12111	121110	Visual arts	2.75 (median of respective Compendium activities)	yes	yes	09020	Miscellaneous: drawing, writing, painting, standing	1.80
							09075	Miscellaneous: sitting, arts and crafts, carving wood, weaving, spinning wool, light effort	1.80
							09080	Miscellaneous: sitting, arts and crafts, carving wood, weaving, spinning wool, moderate effort	3.00
							09085	Miscellaneous: standing, arts and crafts, sand painting, carving, weaving, light effort	2.50
							09090	Miscellaneous: standing, arts and crafts, sand	3.30

							painting, carving, weaving, moderate effort	
						09095	Miscellaneous: standing, arts and crafts, sand painting, carving, weaving, vigorous effort	3.50
12112	121120	Literary arts	1.30 (median of respective Compendium activities)	yes	yes	09040	Miscellaneous: sitting, writing, desk work, typing	1.30
						09060	Miscellaneous: sitting, studying, general, including reading and/or writing, light effort	1.30
						07050	Inactivity quiet/light: reclining, writing	1.30
12113	121130	Performing arts (dance, music, theatre)	4.00 (median of respective Compendium activities)	yes	no	03031	Dancing: general dancing (e.g. disco, folk, Irish step dancing, line dancing, polka, contra, country)	7.80
						03010	Dancing: ballet, modern, or jazz, general, rehearsal or class	5.00
						10074	Music playing: playing musical instruments, general	2.00
						10130	Music playing: marching band, baton twirling, walking, moderate pace, general	4.00
						10131	Music playing: marching band, playing an instrument, walking, brisk pace, general	5.50
						10135	Music playing: marching band, drum major, walking	3.50
						11870	Occupation: working in scene shop, theater actor, backstage employee	3.00
1211x		Visual, literary and performing arts n.f.d.	2.75 (summary assessments)	yes	no			

Notes: Compendium: 2011 Adult Compendium of Physical Activities (Ainsworth et al., 2011); MET: metabolic equivalent of task; ICATUS 2005: Trial International Classification of Activities for Time Use Statistics 2005; n.f.d.: not further defined

MET values and the codes for wakefulness and posture were not assigned to occupational and travel-related activities, because insufficient information is provided in the Guide to Producing Statistics on Time Use (Statistical Division United Nations, 2005) and the ICATUS 2016 document (United Nations Statistics Division, 2017) to be able to make an informed assessment of these ICATUS activities.

Harmonisation of ICATUS 2005 and 2016 activities

Once all subclass activities of the Trial ICATUS 2005 were coded, one author (NL) matched 3-digit activities (the most detailed level) from the ICATUS 2016 with corresponding activities of the Trial ICATUS 2005, where applicable. The description of the activity codes in the Trial ICATUS 2005 and the ICATUS 2016 (Statistical Division United Nations, 2005; United Nations Statistics Division, 2017), including examples and exceptions, was examined for harmonisation purposes. The MET values, wakefulness status, and posture categories assigned to ICATUS 2005 activities were used for their matching ICATUS 2016 activities. For the ICATUS 2016 activities that could not be matched with any ICATUS 2005 activity, we assigned MET values, wakefulness status, and posture separately. Furthermore, some ICATUS 2016 activities were matched with multiple ICATUS 2005 activities. To such activities we also assigned MET values, wakefulness status, and posture separately. An extract from the table used in the described harmonisation process is shown in Table 7.4, while the complete table can be found in Additional File 1.

Table 7. 4 An extract from the table used for the harmonisation of ICATUS 2005 and 2016 activities

ICATUS 2005				ICATUS 2016	
Code			Description	Code	Description
1511			**Sleep and related activities**		
	15111	151110	Night sleep/essential sleep	911	Night sleep/essential sleep
	15112	151120	Incidental sleep/naps	912	Incidental sleep/naps
	15113	151130	Sleeplessness	913	Sleeplessness
	1511x		Sleep and related activities n.f.d.	919	Other sleep and related activities
		03111	Processing of food products	127	Making and processing goods for the market in household enterprises
		03112	Making of other food products and beverages		
		03113	Making textiles, wearing apparel, leather and associated products		
		03114	Craft-making using all types of materials		
		03115	Tobacco preparing and curing		
		03116	Making bricks, concrete slabs, hollow blocks, tiles etc.		
		03117	Making herbal and medicinal preparations		

Notes: ICATUS 2005: Trial International Classification of Activities for Time Use Statistics 2005; ICATUS 2016: International Classification of Activities for Time Use Statistics 2016; n.f.d.: not further defined

Delphi survey

The initial assessment and harmonisation of ICATUS activities were reviewed independently and anonymously by all content experts as part of a Delphi decisional process. The Delphi method consists of a series of anonymous surveys, conducted to achieve a consensus among members of an expert panel, and it is widely used for decision-making. (Hsu & Sandford, 2007). The Delphi survey was conducted using Qualtrics software (Version qualtrics^{XM} of the Qualtrics Research Suite, Qualtrics LLC, Provo, UT, USA), an online survey platform (Qualtrics, 2019). Content experts were grouped into four panels, each consisting of four members. Each panel reviewed approximately 130 activities. Each panel included: i) the initial assessor (NL), who could provide detailed reasoning for every assessment to the other members of the panel; ii) at least one specialist in SB and/or PA epidemiology; iii) at least one specialist in SB and/or PA measurement; iv) at least one specialist in time-use surveys; and

v) researchers from three or more different countries. The Delphi process was moderated by a researcher specialised in SB and PA topics, who was not involved in any of the Delphi panels nor was included in the author team.

At the beginning of the Delphi survey, panellists were given detailed information about the process of classifying the ICATUS activities by METs, wakefulness status, and posture. As part of the survey, each expert panel was asked to review the initial assessments and harmonisation and to express their agreement or provide suggestions for improvement. After each survey round, the moderator summarised the responses from the expert panels and amended the assessments and harmonisation accordingly. The revised list was then circulated among the members of the expert panel as part of the following survey round, to see if any further refinements were needed. A summary report including the original responses from all panel members was sent alongside all subsequent surveys. These steps were repeated until a consensus was reached among all content experts.

An additional panel was formed to review 32 ICATUS 2016 activities that could not be harmonised with a single activity from the Trial ICATUS 2005. We undertook the same Delphi procedures for this additional expert panel as described above.

Results

We assigned MET estimates and codes for wakefulness status and posture to a total of 542 ICATUS activities. In Round 1, experts suggested modifying the original assessments of 91 activities and harmonisation of 3 activities. In Round 2, a consensus on the assessment and harmonisation of ICATUS 2005 and ICATUS 2016 activities was reached by two panels. Further suggestions were received to adjust assessments of 31 activities in the remaining groups. In Round 3, a consensus on the assessment and harmonisation of ICATUS 2005 and ICATUS 2016 activities was reached for the remaining groups. The experts reached consensus for all activities, except for: 131120 *"biking, skating, skateboarding"*; 131150 *"ball* *games, team sports"*; and 131160 *"water sports"*. These activities were assigned 7 METs, 7 METs, and 6 METs, respectively; however, one panel member suggested their metabolic values may be higher. For these activities, we made the final decisions in the third round of the Delphi survey, based on 75% agreement between the experts. The flow of the Delphi process and results of each survey round are outlined in Figure 7.1.

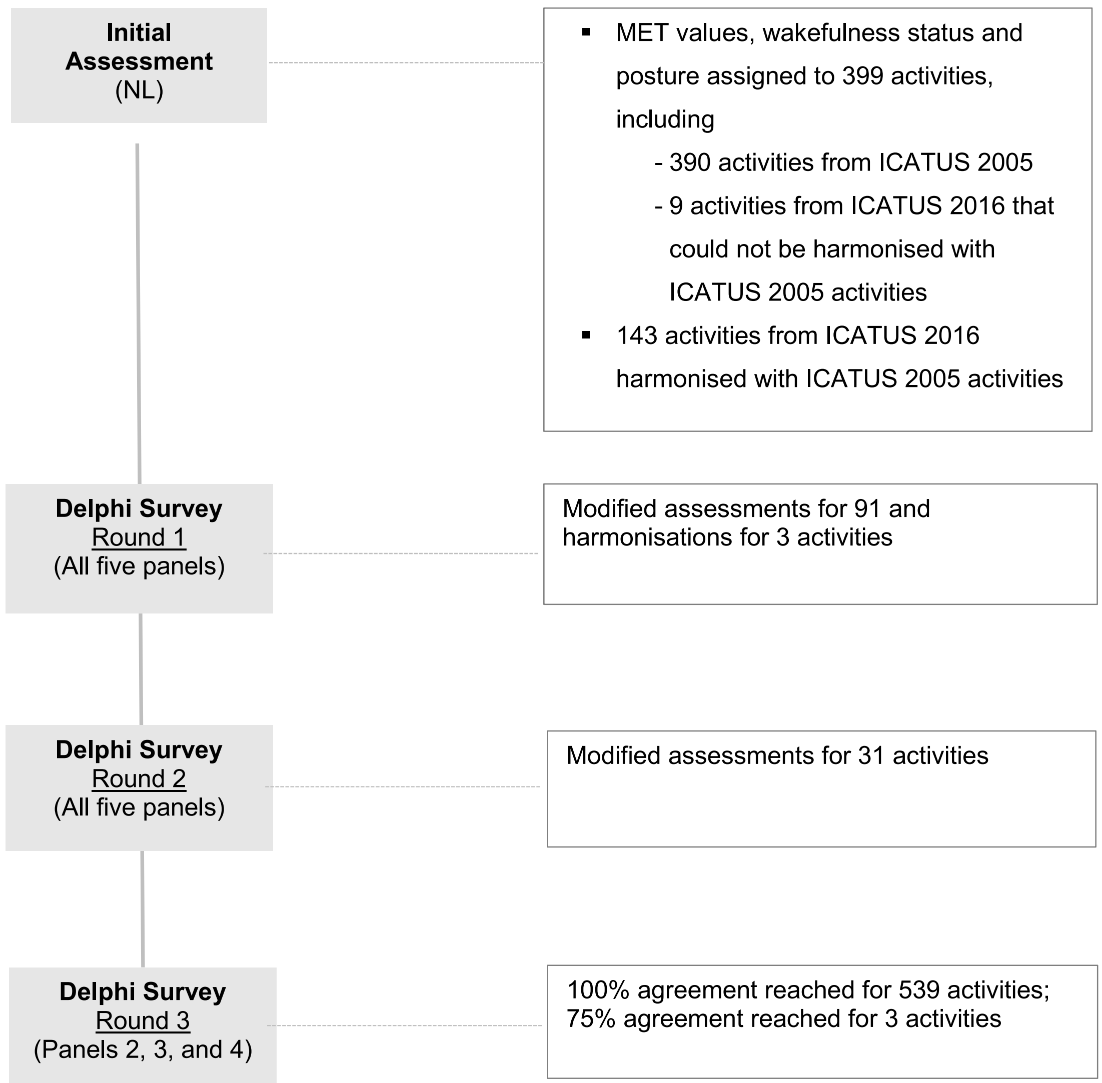

Figure 7. 1 Flow and results of the Delphi process

From a total of 390 activities assessed from the Trial ICATUS 2005, we classified 3 activities into sleep (0.7%), 65 activities into SB (16.7%), 186 activities into LPA (47.7%), and 136 activities into MVPA (34.9%). The summary codes, including the activity-based categories, MET estimates, wakefulness status, and posture assigned to the Trial ICATUS 2005 activities are available in APPENDIX VI.

Of a total of 152 activities assessed from the final ICATUS 2016, we classified 3 activities into sleep (2%), 32 activities into SB (21%), 69 activities into LPA (45.4%), and 48 activities into MVPA (31.6%). We were able to harmonise a vast majority of ICATUS 2016 activities with ICATUS 2005 activities (*n* = 143; 94.1%). The summary codes, including the movement categories, MET estimates, wakefulness status, and posture assigned to the ICATUS 2016 activities are provided in APPENDIX VII. The full assessment and harmonisation tables of ICATUS activities are available in Additional File 1.

Discussion

This is the first study to develop an expert-based classification of ICATUS activities into sleep, SB, LPA, and MVPA categories. We also provided estimated MET values, wakefulness status and posture for ICATUS activities; information that researchers can use for other categorisations (e.g., sleep, SB, LPA, and moderate-vigorous PA). The classification may be considered as the first step towards greater utilisation of ICATUS-based time-use surveys in time-use epidemiology.

To date, it seems that only time-use surveys conducted in high-income countries have been used to estimate SB and PA levels. This includes studies based on ATUS (G. Dunton, D. Berrigan, R. Ballard-Barbash, B. Graubard, & A. Atienza, 2009; G. F. Dunton, D. Berrigan, R. Ballard-Barbash, B. I. Graubard, & A. A. Atienza, 2009; Smith, Ng, & Popkin, 2014; Tudor-Locke & Ham, 2008; Tudor-Locke, Leonardi, et al., 2011; Tudor-Locke et al., 2014; Tudor-Locke et al., 2009), American Heritage Time Use Study (AHTUS) (Archer et al., 2013; Tudor-Locke et al., 2007), GSS-TU (Lachapelle & Pinto, 2016; Millward et al., 2014; J. Spinney & Millward, 2010; J. E. Spinney et al., 2011; J. E. Spinney et al., 2009; Turcotte, 2009), Australian Time Use Survey (Chau et al., 2012; Espinel et al., 2015; Tudor-Locke et al., 2005; van der

Ploeg et al., 2010), the United Kingdom Time Use Survey (Adams, 2010), Belgian Time Use Survey (using HETUS classification) (van Tienoven et al., 2018; Weenas et al., 2019), Multinational Time Use Study (MTUS) (Harms et al., 2019; Ng & Popkin, 2012), Dutch Time Use Survey (Loyen, Chau, Jelsma, van Nassau, & van der Ploeg, 2019), and Halifax Space-Time Activity Research survey (conducted in Halifax, Nova Scotia, Canada) (Millward & Spinney, 2011). To the best of our knowledge, no such studies have been conducted in low- and middle-income countries. ICATUS-based time-use surveys have been conducted in many low-, middle-, and high-income countries (Charmes, 2015; United Nations Statistics Division, 2018). Our results will enable easier utilisation of these abundant data for the purpose of studies in time-use epidemiology. However, more validation studies of time-use surveys for assessing SB and PA are still needed, especially in larger samples and against device-based measures of these behaviours.

It has been suggested that three rounds of Delphi surveys are sufficient to gather key feedback from the panel members (Hsu & Sandford, 2007; Thangaratinam & Redman, 2005). Further rounds are unlikely to provide additional essential information (Hsu & Sandford, 2007; Thangaratinam & Redman, 2005). Percent of agreement between experts in Delphi studies varies from as low as 55% to 100% (Powell, 2003). In the present study, the panel members reached perfect agreement for nearly all activities in no more than three survey rounds. This indicates that the assignment of MET values, wakefulness status, and posture to ICATUS-based time-use categories was relatively straightforward. However, a number of points were raised by experts during the Delphi process, which shows the importance of using a collective (vs individual) approach when developing criteria for classifying time use into activity-based categories. It is possible that more rounds of Delphi surveys would be needed, if the panels included additional members. On the other hand, a large number of points to assess (as in the current study) generally makes reaching consensus more difficult.

Historically, time-use surveys were designed to capture a population’s time budget reflecting on social and economic perspectives such as labour force, unpaid work, work life balance, and gender equality (United Nations Statistics Division, 2017). Estimating MET values for some ICATUS activities was impossible or very challenging. Firstly, there are several broad categories in ICATUS that consist of a wide range of different activities. It was difficult to assign a specific MET value to such categories. For example, the activity 131110 *“walking and hiking; jogging and running”* under group 1311 *“participating in sports”* includes four main activities; namely, walking, hiking, jogging, and running, that can be associated with varying intensities ranging from 3.0 METs (Compendium code 17170 *“walking, 2.5 mph, level, firm surface”*) to 23 METs (Compendium code 12135 *“running, 14 mph (4.3 min/mile)”*) (Ainsworth et al., 2011). Secondly, assigning METs to ICATUS activities in the *“working time in formal sector employment”* (Major division 01 employment) and the travel-related activities was not possible due to insufficient information about these activities. In ICATUS, these activities are classified generally as “working time” and “travel-related” activities. For example, ICATUS code 011110 is defined as “working time in main job”. It is obvious that “working time” defined in such an unspecific way can include any type of work, which can be completely sedentary or extremely physically demanding. Similarly, “travel-related activities” can include any kind of transport, including its active (e.g., cycling) and passive (e.g., going by train) modes. In the current study, these activities were, therefore, coded as “not applicable”. However, for future users of ICATUS-based time-use data, it may be possible to estimate associated METs of these activities, if the participants’ responses are linked with additional, more specific questions about their occupation and modes of travel (Deyaert et al., 2017). Such additional questions are often included in time-use surveys (Deyaert et al., 2017). Once these variables are linked, MET estimates can be assigned using the Compendium (Ainsworth et al., 2011) or from summary MET values previously assigned to a list of occupations (Deyaert et al., 2017; J. E. Spinney et al., 2011; Tudor-Locke, Ainsworth, et al., 2011; Tudor-Locke et al., 2009). Similar difficulties were also reported in previous studies by Tudor-Locke et al. (Tudor-Locke et al., 2009) and Spinney et al. (J. E. Spinney et al., 2011).

There are several strengths of the current study. Firstly, the Delphi panellists were purposefully selected to participate in the study based on their expertise in relevant research fields. Secondly, Delphi panels were formed in a way to ensure representation of varying skills and experience in each panel. Thirdly, we categorised both ICATUS 2005 and ICATUS 2016 activities, which will enable SB and PA researchers to use ICATUS-based time-use data collected over a period of nearly 15 years. Lastly, our harmonisation of ICATUS 2005 and ICATUS 2016 activities will improve the comparability of the derived SB and PA data from the two ICATUS versions.

There are also some limitations in the present study. First, as we needed experts with relevant knowledge in different fields, we included 13 content experts to participate in the Delphi survey. As they were divided into four experts per one Delphi panel, the number of Delphi panellists in this study may be considered small. Despite our effort to recruit panellists with expertise in different areas, it is possible that their consensus does not represent the broader field. It may also be that the relatively small number of panel members negatively impacted the validity of final outcomes of the Delphi process. Another limitation of the study is that we assigned an unweighted median MET value to most ICATUS activities, calculated from the list of matched Compendium activities. A more precise estimation could be achieved by calculating weighted averages, where the weights are proportional to the representation of these activities in the time use of a specific population. This approach has been used with data from the MTUS (Harms et al., 2019), but it depends on an underlying dataset giving the prevalence of component activities. Given that we did not have access to such data as part of this study and that our study was not intended to focus on a specific population, we provided generic, non-weighted estimates. Furthermore, the MET values we used from the Compendium quantify energy costs of physical activities in healthy, 18 – 65 year old adults (Ainsworth et al., 2011). The MET values applied to ICATUS activities should not be interchanged with those identified in the Compendium. Therefore, our estimates are only applicable to healthy adults for analysis of ICATUS data. Detailed tables, including the lists of matched activities from the Compendium and calculations of summary METs are available in Additional File 1, if any adaptations to a specific population is required in future studies.

Conclusion

In this study, a group of 13 content experts in measurement, epidemiology and time use reached a consensus about the estimated MET values, wakefulness status and posture of ICATUS 2005 and ICATUS 2016 activities. This has enabled categorisation of ICATUS activities into sleep, SB, LPA, and MVPA categories, which may encourage greater utilisation of data from time-use surveys in public health research. The generic estimates and categorisations we provided may be used or further adapted to better reflect the time-use patterns of specific study populations. Future research needs to assess the validity and reliability of SB and PA estimates from ICATUS-based time-use surveys. Provided the measurement properties are adequate, the new categorisation system can then be used in studies exploring the patterns, trends, determinants, and outcomes of sleep, SB, LPA, and MVPA.

List of abbreviations

- American Heritage Time Use Study (AHTUS)
- American Time Use Survey (ATUS)
- Harmonised European Time Use Survey (HETUS)
- International Classification of Activities for Time-Use Statistics (ICATUS)
- International Standard Classification of Occupations (ISCO)
- Light Physical Activity (LPA)
- Metabolic Equivalent of Task (MET)

- Moderate-to-Vigorous Physical Activity (MVPA)
- Multinational Time Use Study (MTUS)
- Physical Activity (PA)
- Sedentary Behaviour (SB)
- Standard Industry Codes (SIC)
- Standard Occupational Classification (SOC)
- Statistics Canada's General Social Survey – Time Use (GSS-TU)
- Tecumseh Occupational Physical Activity Questionnaire (TOPAQ)
- United Nations Statistics Division (UNSD)
- Viable Integrative Research in Time-Use Epidemiology (VIRTUE)

Additional Files

Additional File 1

File name: Additional file 1_full assessment and harmonisation tables.xlsx

Title: ICATUS Assessment and Harmonisation Tables

Description: The full assessment and harmonisation tables of ICATUS activities

Additional File 2

File name: Additional file 2_assignments to 2005 ICATUS activities.pdf

Title: 2005 ICATUS Assignment Table

Description: Metabolic equivalent (MET) values, summary codes and movement categories assigned to 2005 International Classification of Activities for Time Use Statistics (ICATUS) activities

Additional File 3

File name: Additional file 3_ assignments to 2016 ICATUS activities.pdf

Title: 2016 ICATUS Assignment Table

Description: Metabolic equivalent (MET) values, summary codes and movement categories assigned to 2016 International Classification of Activities for Time Use Statistics (ICATUS) activities

Declarations

Ethics approval

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The assessment of ICATUS activities is available in Tables, Figure, and Supplementary materials.

Competing interests

The authors declare no competing interests.

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Authors' contributions

NL and ZP conceived the idea for the study. NL led the writing of the study protocol. NL, ZP, MC, SJHB, DD, CTL, BA, CJ, TPvT, UL, DW, DB, and TO conceptualised the study. NL conducted the initial assessment and harmonisation of ICATUS activities. NL, ZP, MC, and SJHB designed the Delphi survey. ZP conducted a review of the initial assessment and harmonisation for a pilot sample of ICATUS activities. NL, ZP, MC, DD, SJHB, CTL, BA, CJ, TPvT, UL, DW, DB, and TO participated as panel members in the Delphi decisional process. NL classified the ICATUS activities and prepared summary tables. NL drafted the manuscript. ZP, MC, DD, SJHB, CTL, BA, CJ, TPvT, UL, DW, DB, and TO contributed to writing the manuscript. All authors read and approved the final draft.

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CHAPTER VIII: Trends and Correlates of Meeting 24-Hour Movement Guidelines: a 15-year Study among 167,577 Thai Adults

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Trends and Correlates of Meeting 24-Hour Movement Guidelines: a 15-year Study among 167,577 Thai Adults

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Abstract

Background

Time spent in physical activity (PA), sedentary behaviour (SB), and sleep always takes up the whole day. New public health guidelines combining recommendations for PA, SB, and sleep have been issued in several countries. Thailand was the first country to release the 24-hour guidelines for adults. Currently, there is no evidence on the population prevalence of meeting 24-hour movement guidelines in Thailand. This study, therefore, aimed to determine 15-year trends and associations of meeting 24-hour movement guidelines among Thai adults.

Method

We analysed data from 2001, 2004, 2009, and 2015 Thai Time-Use Surveys, coded using the International Classification of Activities for Time-Use Statistics (ICATUS). All ICATUS-based activities were categorised into moderate-to-vigorous PA (MVPA), light PA (LPA), SB, and sleep based on a previously developed classification system. A total of 167,577 adult participants were included. The participants were classified according to the Thai 24-hour movement guidelines into meeting or not meeting the following criteria: 1) ≥150 minutes/week of MVPA; 2) interrupting SB every 2 hours; 3) sleeping 7 – 9 hours per day; and 4) adhering to all three guidelines.

Results

In 2015, the prevalence of adults who met the MVPA, SB, sleep, and overall recommendations was 81.7%, 44.6%, 56.4%, and 21.3%, respectively. A significant linear increase was found for the prevalence of meeting the SB recommendation, while the prevalence meeting the MVPA, sleep, and overall recommendations was lowest in 2001, peaked in 2004 or 2009, and declined in 2015. The lowest odds for meeting the 24-hour guidelines were found among males, those living in urban areas, inhabitants of Bangkok and South Thailand, unemployed, and those with low education level.

Conclusions

Despite promising trends in the prevalence of meeting PA, SB, and sleep recommendations, a majority of Thai adults still do not meet the overall 24-hour movement guidelines. Further actions are needed to promote more MVPA, less SB, and adequate sleep in Thai adults, particularly among males, those living in urban areas, inhabitants of Bangkok and South Thailand, unemployed, and those with low education level.

Keywords

Time-use data, Physical activity, Sedentary behaviour, Sleep, ICATUS, Time-use epidemiology

Background

Given that everyone has a fixed 24-hour budget in a day and the time spent in physical activity (PA), sedentary behaviour (SB), and sleep always takes up the whole day, any change in the time spent in one of these behaviours necessarily affects the remaining behaviours (1-4). Recent epidemiological research has therefore often considered these behaviours collectively in relation to health. Growing evidence shows that high PA, low sedentary time, and adequate sleep duration are collectively associated with a range of health benefits, such as lower body mass index (BMI), low waist circumference, and high aerobic fitness (5-10). Based on the emerging evidence and a better understanding of the importance of considering these behaviours holistically, new public health guidelines that combine recommendations for PA, SB, and sleep have been issued in several countries (11-19). Canada pioneered the development of such guidelines, and in 2016 they launched the first national 24-hour movement guidelines (16). Soon after, following the Canadian example, Australia, Finland, New Zealand, South Africa, and Thailand issued their 24-hour movement guidelines (11-15). To date, a few additional countries, such as Croatia and the United Kingdom, have made initial steps in the process of adopting similar public health guidelines (17, 18). The World Health Organization (WHO) supported the integrative approach to movement behaviours and has recently released 24-hour guidelines for children under 5 years of age (19).

Time-use surveys provide comprehensive data on common activities that the general population performs in a day (20). Since the 1960s, time-use data have been collected worldwide in over 85 countries (20). With contextualised information across life domains and international availability, these surveys have been a valuable source of data for epidemiological research on movement behaviours (21).

To facilitate the use of time-use survey data in epidemiological research, metabolic equivalent (MET) values can be assigned to the time-use activity codes. Several time-use surveys, such as the American Time-Use Survey (ATUS), Australian Time Use, Belgium Time-Use Survey, Canada’s General Social Survey – Time Use (GSS-TU), and International Classification of Activities for Time-Use Statistics (ICATUS) have used the Compendium of Physical Activities (22) to assign time-use activity codes with METs (22-29). Time-use surveys provide sufficiently accurate PA estimates for observational studies (25, 30), and are considered as a useful tool for the integrated research on movement behaviours (3, 21, 31).

To date, time-use data have been used to examine population prevalence and correlates of PA and SB, particularly in high-income countries (24, 25, 27, 32-40). Some studies also used time-use survey data to explore the prevalence of PA/SB or meeting PA recommendations and trends over time (23, 28, 41, 42). Meeting the 24-hour movement guidelines has started to gain momentum in national health monitoring studies (43), and several studies have examined associations of meeting the guidelines with health and psychological wellbeing among youth (44-46). However, no studies have employed data from time-use surveys to determine the prevalence of meeting 24-hour movement guidelines.

In 2017, Thailand issued holistic, national 24-hour movement guidelines for five different population groups (13). These include 1) pregnant and postpartum women; 2) early years (0 – 5 years); 3) school-aged children and adolescents (6 – 17 years); 4) adults (18 – 59 years); and 5) older adults (60 years and older). To our knowledge, Thailand issued the first 24-hour movement guidelines, including PA, SB, and sleep recommendations for adults, older adults, and pregnant and postpartum women. In 2001, the Thai National Statistical Office (NSO) collected time-use data in a population-representative sample of adults using ICATUS-based surveys, with repeated data collections planned for every four to five years. The subsequent surveys occurred in 2004, 2009, and 2015 (47-50). The recently developed system for categorizing ICATUS activities into sleep, SB, light PA (LPA), and moderate-to-vigorous PA (MVPA) now allows researchers to use Thai national time-use surveys (and other ICATUS-based surveys) to determine the prevalence of meeting 24-hour guidelines (26).

Currently, there is no evidence on the population prevalence of meeting 24-hour movement guidelines in Thailand. There is also a lack of evidence on PA and SB trends in the Thai population (51). In addition, the authors are not aware of any studies that have examined the temporal changes of factors associated with meeting the integrated movement guidelines. This study, therefore, aims to determine 15-year trends of meeting 24-hour movement guidelines and to examine how associations between sociodemographic variables and meeting these recommendations have changed over time.

Methods

Thai National Time-Use Survey

The NSO conducted cross-sectional Thai National Time-Use Surveys in 2001, 2004, 2009, and 2015 (47-50). The NSO randomly selected private households by using the three-stage stratified sampling method (47-50). The stratification was based on five Thai regions (Bangkok, Central, North, North-East, and South), 77 provinces, and municipal and non-municipal areas (47-50). Data were collected among Thai citizens in the selected households who were aged at least 10 years in the survey years 2001, 2004, and 2009 and 6 years in the 2015 survey year, by a combination of a direct interview and self-administered questionnaires. The NSO trained officers recorded participants' daily activities over the specific 24-hour day (from 0:00 to 24:00 h) using a computer-assisted coding device. The surveys captured main (primary) activities within 10-minute intervals. If more than one activity was performed simultaneously, a secondary activity was also recorded. The surveys also included household and individual questionnaires to gather sociodemographic information about respondents. This study analysed time-use data from all four survey years.

Ethics approval and consent

The NSO is a state agency responsible for a production of statistical data for the national development. The agency is enacted by the Official Information Act, B.E. 2540 (1997) (52). In accordance with the Official Information Act, participants' informed consent was given prior to the survey and their anonymity and confidentiality of their data were protected by the legislation (52). For this study, we obtained a permission from the NSO to access microdata of four time-use surveys for research purposes only.

Participants

This study included only adult participants (18 – 59 years old) with complete 24-hour data. We applied this age range based on the Thai Labour Protection Act (No. 6), B.E. 2560 (2017), which specifies the retirement age for adults at 60 years and above (53). The total pooled sample size from four survey years was 167,577 (n = 37,702 in 2001; n = 37,544 in 2004; n = 45,751 in 2009; and n = 46,580 in 2015).

Measures and data processing

The time-use data were coded using ICATUS classification. The time-use codes from the survey year 2001 were based on the Draft ICATUS comprising 10 major groups of activities (49). The other survey years used the Trial ICATUS consisting of 15 major groups of activities (47, 48, 50). The Trial ICATUS is a revised version of the Draft ICATUS (54). One author (NL) harmonised activities in the Draft ICATUS with corresponding activities from the Trial ICATUS. Once all activities were matched, they were categorised into sleep, SB, LPA, and MVPA based on the classification system previously developed for the Trial ICATUS (26). A detailed description of the method used to classify ICATUS activities can be found elsewhere (26). Due to insufficient information provided for occupational and travel-related activities in ICATUS, this classification system did not apply to such activities. Instead, the reported occupational and travel-related activities were linked with additional information on occupations and location or mode of travel of respondents available in the household questionnaires, according to the procedures suggested in previous studies (26, 28, 29). The occupations of respondents were linked with a summary MET previously assigned to the occupation list of 2008 International Standard Classification of Occupations (ISCO-08) (55). For travel-related codes, the location or mode of travel of respondents was linked with a summary MET assigned to travelling modes available in a previous study (29).

Once all ICATUS-based activities from 2001, 2004, 2009, and 2015 were categorised into sleep, SB, LPA, and MVPA, the time (in minutes) spent in each of the behaviours was calculated. Each participant was categorised as either “meeting” or “not meeting” the Thai 24-hour movement guidelines for adults. The guidelines include the following recommendations: 1) to engage in at least 150 minutes/week of moderate PA, or 75 minutes/week of vigorous PA, or an equivalent combination of the two PA intensities; 2) to interrupt SB every 2 hours; and 3) to sleep between 7 and 9 hours per day (13). The guidelines also include an MVPA recommendation for additional health benefits, defined as at least 300 minutes/week of moderate PA, or 150 minutes/week of vigorous PA, or an equivalent combination of the two PA intensities (13). The participants who met all three recommendations for MVPA, SB, and sleep, were categorised as meeting the overall 24-hour movement guidelines.

Given that several ICATUS activity groups are broad, it is not feasible to distinguish activities of moderate and vigorous intensity (26). Following the previously developed classification of ICATUS activities, a combination of moderate and vigorous intensities (i.e., MVPA) were used. The amount of time spent in MVPA, SB, and sleep was calculated and used to determine whether participants met the recommendations. For meeting the MVPA recommendation, participants who engaged in a minimum of 150 minutes/week of MVPA, which translates into an average of approximately 22 minutes/day, were categorised as meeting the MVPA recommendation. For the SB recommendation, participants who spent no more than 120 minutes in a single SB activity or simultaneous SB activities throughout the day were classified as meeting the recommendation. Finally, participants who slept between 420 and 540 minutes per day were classified as meeting the sleep recommendation.

Recommendation for muscle-strengthening activities is also a part of the guidelines (13). However, in ICATUS-based time-use surveys, these activities are broadly grouped in fitness-related category which includes yoga and other aerobic activities (56). It was, therefore, not possible to determine whether participants met the recommendation for muscle-strengthening activities.

In the analyses, eight sociodemographic variables reported in all four survey years were included. These comprised sex (male, female), age groups (18 – 29 years, 30 – 39 years, 40 – 49 years, and 50 – 59 years), region (Bangkok, Central, North, North-East, and South), household area (urban, rural), employment status (employed, unemployed), highest education level (none, primary school, secondary school, higher education, and unspecified), marital status (never married, married, formerly married), and religion (Buddhist, non-Buddhist).

Data analysis

All data were weighted using the population weights provided by NSO, to represent the Thai adult population. Additional weights were used to adjust for slight discrepancies from the assumed uniform distribution of surveys across the seven days of the week. Percentages (and their 95% confidence intervals [CI]) of participants meeting MVPA, SB, Sleep, and overall 24-hour movement recommendations were computed for the overall sample and by the sociodemographic categories. A series of multivariate logistic regressions was performed to examine the associations between the sociodemographic variables and participants' compliance within the 24-hour movement guidelines. The adjusted odds ratios (OR) and their 95% CI were calculated. A series of mixed-effects meta-regression analyses with Restricted Maximum Likelihood Estimation (REML) were used to establish the time-trends in prevalence estimates and the time-trends in the associations of sociodemographic variables with meeting the 24-hour movement guidelines. Linear and quadratic functions were fitted to each time-trend, and the model with the lower Akaike Information Criterion (AIC) value was selected. The statistical significance level was set at $p<0.05$. All analyses were conducted in R (R Foundation for Statistical Computing, Vienna, Austria), using "questionr" and "metafor" packages (57, 58).

Results

Sample characteristics

The weighted sample included nearly equal of males and females (Table 1). In 2001, the most represented age group were young adults (18-29 years old), but the prevalence of older age groups continuously increased throughout the 15-year period. In the first three survey rounds, around two thirds of participants lived in rural areas. From 2009 to 2015 there was a large reallocation from rural to urban areas, resulting in a nearly equal split in the final survey year. In 2001, the most represented region in the sample was North-East (33.8%), while the largest percentage of participants in 2015 were from the Central region (30.4%). In all survey years, most participants were married, Buddhist, and employed. In 2001, primary school was the highest level of education for most participants (60.2%). However, the level of education attainment increased during the study period, as more people completed secondary or higher education.

Table 8. 1 Characteristics of the weighted samples in the 2001, 2004, 2009, and 2015 Thai Time-Use Surveys

Sociodemographic variable	2001	2004	2009	2015
Total (*n*)	37702	37544	45751	46580
Sex (%)				
Male	49.8	50.1	49.2	49.0
Female	50.2	49.9	50.8	51.0
Age groups (%)				
18 - 29	35.4	34.3	29.6	27.5
30 - 39	27.4	27.2	26.2	24.5
40 - 49	22.5	22.8	25.5	26.1
50 - 59	14.7	15.7	18.7	22.0
Household area (%)				
Urban	32.3	34.6	32.7	46.9
Rural	67.7	65.4	67.3	53.1
Region (%)				
Bangkok	12.1	14.2	11.1	15.0
Central	22.9	23.7	24.5	30.4
North	19.0	18.2	18.3	16.3
North-East	33.8	31.6	32.8	25.2
South	12.3	12.2	13.2	13.2
Marital status (%)				
Never married	24.4	24.6	23.1	27.7
Married	69.7	69.6	70.1	64.5
Formerly married	5.9	5.7	6.8	7.8
Religion (%)				
Buddhist	95.1	95.3	95.1	95.4
Non-Buddhist	4.9	4.7	4.9	4.6
Employment status (%)				

Sociodemographic variable	2001	2004	2009	2015
Employed	82.4	82.4	83.1	80.8
Unemployed	17.6	17.6	16.9	19.2
Highest education level (%)				
None	3.2	3.1	4.5	9.8
Primary	60.2	54.6	47.9	35.2
Secondary	25.7	29.2	30.0	31.5
Higher education	10.7	12.7	17.3	23.0
Unspecified	0.2	0.3	0.2	0.5

Prevalence of meeting the MVPA recommendations

In 2015, the prevalence of Thai adults meeting the MVPA recommendations was 81.7% (95% CI: 81.3, 82.1). For the whole sample, and for all but one sociodemographic group, the sample prevalence of adults meeting the MVPA recommendations was the lowest in 2001, peaked in 2004 or 2009 and then declined in 2015. However, such inverted U-shaped trend was found to be significant only among males, those aged 50-59 years, inhabitants of urban areas, formerly married, non-Buddhists, the unemployed, and those who did not attend school or had secondary education.

The prevalence of Thai adults who met the MVPA recommendations for additional health benefits was 74.3% (95% CI: 73.9, 74. 7) in 2015 (APPENDIX VIII). For the overall sample and for most sociodemographic groups, the sample prevalence was lowest in 2001, rose to its highest point in 2004 and 2009, and then declined in 2015. However, this inverted U-shaped trend was found to be significant only among those who were aged 50 – 59 years, formerly married, and with unspecified level of education.

Associations of sociodemographic characteristics with meeting the MVPA recommendations

In all survey years, older age groups (i.e., 40 – 49 years and 50 – 59 years) had higher odds of meeting the MVPA recommendations, compared to the youngest adult group (18 – 29 years; Table 2). Rural residents had 95%, 45%, 19% and 19% higher odds of meeting the recommendation than those who lived in urban areas in 2001, 2004, 2009, and 2015, respectively (*p*-value for linear trend = 0.042). Those who lived in Bangkok had the lowest odds, while the participants from the North region had the highest odds of meeting the recommendations (in all years except in 2001). An inverted U-shaped trend was found for the odds ratios for the North region, where the odds rose from 2001 to 2009 and then dropped in 2015 (p = 0.025). In most survey years, significantly higher odds of meeting the MVPA recommendations were also found for those who were married (compared to those who have never been married), non-Buddhists (compared to Buddhists), and employed (compared to unemployed). Regarding level of education, the lowest odds of meeting the MVPA recommendations were found for those with no formal education.

In all survey years, males had higher odds of meeting the MVPA recommendations for additional health benefits, compared to females (APPENDIX VIII). Older ages (30 – 59 years) also had higher odds of meeting the recommendations than the youngest adult group (18-29 years). The odds of meeting the recommendations were 2.09, 1.54, 1.35, and 1.27 times higher among rural residents, compared with those who lived in urban areas in 2001, 2004, 2009, and 2015, respectively (p-value for linear trend = 0.039). Thai adults who lived in Bangkok had the lowest odds of meeting the recommendations, while those who lived in the North region had the highest odds in all survey years except in 2001. In all survey years, higher odds of meeting the recommendations were also found to be significant for those who were non-Buddhists (compared to Buddhists), and employed (compared to unemployed). For the education level, Thai adults who did not attend school had the lowest odds of meeting the recommendations in all survey years except in 2001. An inverted U-shaped trend was found for the odds ratios for those who had higher education, where the odds increased from 2001 to 2009 and then declined in 2015 (p = 0.004).

Table 8. 2 Meeting the moderate-to-vigorous physical activity guideline: population prevalence and associations with sociodemographic variables

Sociodemographic variable	**Percentage (95% CI)**					**Adjusted OR (95% CI)**				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Total (*n*)	73.2 (72.8 - 73.7)	88.1 (87.7 - 88.4)	87.6 (87.3 - 87.9)	81.7 (81.3 - 82.1)	0.078**					
Sex										

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Male	73.7 (73.1 - 74.4)	89.2 (88.7 - 89.6)	89.6 (89.2 - 90.0)	83.6 (83.1 - 84.0)	0.024**	Ref				
Female	72.7 (72.1 - 73.3)	87.0 (86.5 - 87.5)	85.6 (85.2 - 86.1)	79.9 (79.4 - 80.4)	0.151**	1.01 (0.96 - 1.06)	0.96 (0.90 - 1.03)	0.74 (0.70 - 0.78)	0.82 (0.78 - 0.86)	0.269*
Age										
18 - 29	67.9 (67.1 - 68.7)	85.0 (84.4 - 85.6)	83.9 (83.2 - 84.5)	77.5 (76.8 - 78.2)	0.127**	Ref				
30 - 39	73.4 (72.6 - 74.3)	88.4 (87.8 - 89.1)	86.7 (86.1 - 87.3)	80.2 (79.5 - 81.0)	0.171**	1.18 (1.10 - 1.26)	1.04 (0.95 - 1.13)	1.19 (1.10 - 1.29)	1.06 (0.99 - 1.13)	0.811*
40 - 49	77.3 (76.4 - 78.2)	91.0 (90.4 - 91.6)	90.6 (90.1 - 91.2)	84.3 (83.7 - 85.0)	0.054**	1.36 (1.26 - 1.47)	1.38 (1.25 - 1.54)	1.70 (1.55 - 1.86)	1.24 (1.15 - 1.33)	0.818*
50 - 59	79.5 (78.4 - 80.5)	89.7 (88.9 - 90.5)	90.4 (89.8 - 91.0)	85.5 (84.8 - 86.1)	0.005**	1.48 (1.36 - 1.62)	1.23 (1.10 - 1.39)	1.71 (1.55 - 1.89)	1.31 (1.21 - 1.42)	0.887*
Household area										
Urban	57.6 (56.8 - 58.5)	81.2 (80.5 - 81.8)	82.4 (81.8 - 83.0)	77.3 (76.7 - 77.8)	0.034**	Ref				
Rural	80.8 (80.3 - 81.3)	91.6 (91.3 - 92.0)	90.0 (89.7 - 90.3)	85.6 (85.2 - 86.1)	0.237**	1.95 (1.84 - 2.07)	1.45 (1.33 - 1.57)	1.19 (1.10 - 1.28)	1.19 (1.12 - 1.26)	0.042*
Region										

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Bangkok	49.9 (48.4 - 51.3)	73.0 (71.7 - 74.2)	73.3 (72.1 - 74.6)	67.7 (66.6 - 68.8)	0.069**	Ref				
Central	67.5 (66.6 - 68.5)	86.7 (86.0 - 87.4)	84.0 (83.3 - 84.7)	78.6 (77.9 - 79.3)	0.278**	1.21 (1.11 - 1.31)	1.80 (1.62 - 1.99)	1.76 (1.61 - 1.94)	1.58 (1.47 - 1.70)	0.497*
North	78.7 (77.8 - 79.7)	93.1 (92.5 - 93.7)	92.7 (92.2 - 93.3)	89.3 (88.6 - 90.0)	0.107**	1.82 (1.66 - 1.99)	3.54 (3.11 - 4.03)	4.12 (3.66 - 4.64)	3.46 (3.14 - 3.81)	0.025**
North-East	82.0 (81.3 - 82.7)	91.7 (91.2 - 92.2)	90.7 (90.3 - 91.2)	85.9 (85.3 - 86.5)	0.122**	2.21 (2.02 - 2.41)	2.73 (2.44 - 3.06)	3.20 (2.88 - 3.55)	2.48 (2.29 - 2.70)	0.708*
South	74.9 (73.6 - 76.1)	90.9 (90.0 - 91.7)	90.3 (89.6 - 91.0)	87.3 (86.5 - 88.2)	0.140**	1.49 (1.35 - 1.65)	2.49 (2.17 - 2.87)	2.92 (2.59 - 3.30)	2.77 (2.51 - 3.06)	0.080*
Marital status										
Never married	65.4 (64.5 - 66.4)	82.6 (81.8 - 83.4)	82.7 (82.0 - 83.4)	76.9 (76.1 - 77.6)	0.056**	Ref				
Married	76.0 (75.4 - 76.5)	90.4 (89.7 - 90.4)	89.2 (88.8 - 89.5)	83.7 (83.3 - 84.1)	0.119**	0.97 (0.91 - 1.04)	1.24 (1.14 - 1.34)	1.22 (1.13 - 1.31)	1.13 (1.06 - 1.20)	0.664*
Formerly married	73.1 (71.3 - 75.0)	86.9 (85.8 - 88.3)	87.5 (86.3 - 88.6)	82.5 (81.2 - 83.7)	0.024**	0.82 (0.73 - 0.92)	0.95 (0.81 - 1.11)	1.09 (0.96 - 1.24)	1.04 (0.93 - 1.15)	0.477*
Religion										

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Buddhist	72.9 (72.5 - 73.4)	88.0 (87.6 - 88.3)	87.4 (87.1 - 87.7)	81.5 (81.1 - 81.8)	0.082**	Ref				
Non-Buddhist	78.8 (77.0 - 80.7)	90.4 (89.0 - 91.7)	90.7 (89.5 - 91.9)	86.3 (84.9 - 87. 8)	0.020**	1.44 (1.27 - 1.63)	1.2 (1.01 - 1.45)	1.49 (1.28 - 1.75)	1.25 (1.09 - 1.43)	0.831*
Employment status										
Employed	74.8 (74.3 - 75.3)	90.5 (90.2 - 90.8)	89.1 (88.8 - 89.4)	83.3 (82.9 - 83.7)	0.168**	Ref				
Unemployed	65.6 (64.5 - 66.8)	76.6 (75.6 - 77.6)	80.1 (79.3 - 81.0)	75.0 (74.1 - 75.9)	< 0.001**	0.74 (0.69 - 0.78)	0.41 (0.38 - 0.44)	0.59 (0.55 - 0.63)	0.63 (0.59 - 0.66)	0.947*
Highest education level										
None	79.9 (77.6 - 82.2)	84.4 (82.4 - 86.5)	84.6 (83.1 - 86.2)	78.6 (77.4 - 79.8)	< 0.001**	Ref				
Primary	80.7 (80.2 - 81.2)	91.0 (90.6 - 91.4)	89.9 (89.5 - 90.3)	86.6 (86.1 - 87.1)	0.707*	1.06 (0.91 - 1.22)	1.67 (1.40 - 1.99)	1.39 (1.22 - 1.59)	1.54 (1.41 - 1.68)	0.460*
Secondary	63.2 (62.2 - 64.1)	84.5 (83.8 - 85.2)	86.4 (85.8 - 86.9)	80.3 (79.6 - 80.9)	0.009**	0.62 (0.53 - 0.72)	1.45 (1.21 - 1.74)	1.42 (1.24 - 1.62)	1.21 (1.12 - 1.32)	0.113**
Higher education	53.7 (52.1 - 55.2)	84.5 (83.5 - 85.6)	83.7 (82.9 - 84.5)	77.6 (76.8 - 78.3)	0.125**	0.44 (0.38 - 0.52)	1.43 (1.18 - 1.72)	1.38 (1.20 - 1.59)	1.27 (1.16 - 1.39)	0.122**

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Unspecified	56.1 (45.3 - 66.8)	89.1 (83.6 - 94.6)	87.5 (81.5 - 93.6)	76.9 (71.6 - 82.2)	0.085**	0.51 (0.32 - 0.82)	2.87 (1.62 - 5.49)	1.46 (0.84 - 2.71)	1.04 (0.76 - 1.42)	0.558**

Legend: CI = confidence interval; OR = odds ratio; ref = reference group; * = linear model; ** = quadratic model

Prevalence of meeting the SB recommendation

In 2015, the prevalence of Thai adults who met the SB recommendation was 44.6% (95% CI: 44.1, 45.0). A significant linear increase was found for the whole sample, males, all age groups above 30 years of age, those who lived in urban or rural areas, residents of all regions except the North, those who were married and those who have never been married, Buddhists, employed, and those with primary and secondary education. The sample prevalence of adults aged 18-29 years, unemployed, and those with higher education was found to be lowest in 2001, rose to its highest in 2009, and then declined in 2015 (*p*-value for inverted U-shaped trend < 0.05).

Associations of sociodemographic characteristics with meeting the SB recommendation

In 2001, 2004, 2009, and 2015, females had 23%, 47%, 85%, and 44%, respectively, higher odds of meeting the SB recommendation than males (Table 3). The youngest adult group (18-29 years) had the highest odds of meeting the recommendation compared to the remaining age groups. Those who lived in urban areas had higher odds of meeting the recommendation than those who lived in rural areas in all survey years except in 2001. Significantly higher odds of meeting the SB recommendation were also found among those who were married or formerly married (compared to those who have never been married), and employed (compared to unemployed). For those who had higher education, the odds of meeting the SB recommendation rose from 2001 to 2009 and dropped in 2015 (quadratic trend $p = 0.048$).

Table 8. 3 Meeting the sedentary behaviour guideline: population prevalence and associations with sociodemographic variables

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Total (*n*)	36.9 (36.5 - 37.4)	39.6 (39.1 - 40.1)	44.7 (44.2 - 45.1)	44.6 (44.1 - 45.0)	0.002*					
Sex										
Male	35.7 (35.0 - 36.4)	36.4 (35.7 - 37.0)	38.5 (37.8 - 39.1)	41.7 (41.0 - 42.3)	< 0.001*	Ref				
Female	38.2 (37.5 - 38.9)	42.9 (42.2 - 43.6)	50.7 (50.1 - 51.4)	47.4 (46.8 - 48.0)	0.079*	1.23 (1.18 - 1.29)	1.47 (1.40 - 1.53)	1.85 (1.78 - 1.93)	1.44 (1.38 - 1.50)	0.147**
Age										
18 - 29	34.1 (33.3 - 34.9)	37.9 (37.1 - 38.7)	41.8 (41.0 - 42.6)	41.8 (40.9 - 42.6)	< 0.001**	Ref				
30 - 39	39.2 (38.3 - 40.1)	42.6 (41.7 - 43.6)	49.8 (48.9 - 50.7)	48.0 (47.1 - 48.9)	0.025*	0.88 (0.83 - 0.94)	0.88 (0.83 - 0.94)	1.07 (1.01 - 1.13)	0.95 (0.90 – 1.00)	0.632*
40 - 49	39.3 (38.3 - 40.4)	40.2 (39.2 - 41.3)	44.1 (43.2 - 45.0)	45.6 (44.7 - 46.5)	< 0.001*	0.83 (0.78 - 0.89)	0.77 (0.72 - 0.82)	0.80 (0.75 - 0.85)	0.80 (0.75 - 0.85)	0.952*
50 - 59	35.9 (34.6 - 37.2)	37.3 (36.1 - 38.5)	42.9 (41.9 - 44.0)	43.1 (42.1 - 44.1)	0.001*	0.76 (0.71 - 0.82)	0.70 (0.65 - 0.75)	0.81 (0.75 - 0.86)	0.76 (0.71 - 0.81)	0.856*
Household area										

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Urban	34.9 (34.1 - 35.7)	38.3 (37.4 - 39.1)	45.5 (44.7 - 46.3)	45.2 (44.6 - 45.9)	0.002*	Ref				
Rural	37.9 (37.3 - 38.5)	40.3 (39.7 - 40.9)	44.3 (43.7 - 44.8)	44.0 (43.4 - 44.6)	0.005*	0.96 (0.91 - 1.02)	0.93 (0.87 - 0.98)	0.90 (0.86 - 0.95)	0.94 (0.90 - 0.98)	0.935*
Region										
Bangkok	35.1 (33.7 - 36.5)	35.6 (34.3 - 36.9)	44.2 (42.8 - 45.6)	46.4 (45.2 - 47.6)	< 0.001*	Ref				
Central	35.1 (34.1 - 36.1)	39.5 (38.5 - 40.5)	45.9 (44.9 - 46.8)	44.2 (43.4 – 45.0)	0.029*	0.89 (0.82 - 0.97)	1.11 (1.02 - 1.20)	1.12 (1.04 - 1.21)	0.85 (0.80 - 0.91)	0.677*
North	39.4 (38.3 - 40.6)	46.3 (45.1 - 47.4)	46.5 (45.5 - 47.6)	46.8 (45.7 - 47.9)	0.137*	0.98 (0.90 - 1.08)	1.46 (1.34 - 1.59)	1.16 (1.06 - 1.25)	0.99 (0.92 - 1.07)	0.623*
North-East	38.2 (37.4 - 39.1)	39.0 (38.2 - 39.9)	43.2 (42.5 - 44.0)	42.4 (41.5 - 43.3)	0.022*	0.96 (0.88 - 1.05)	1.04 (0.96 - 1.13)	1.03 (0.95 - 1.12)	0.84 (0.78 - 0.90)	0.548*
South	35.0 (33.6 - 36.4)	35.9 (34.5 - 37.3)	44.0 (42.7 - 45.2)	44.8 (43.6 - 46.1)	0.001*	0.85 (0.77 - 0.94)	0.95 (0.86 - 1.05)	1.03 (0.94 - 1.12)	0.90 (0.83 - 0.98)	0.878*
Marital status										
Never married	26.9 (26.0 - 27.8)	30.8 (29.9 - 31.7)	36.5 (35.5 - 37.4)	37.1 (36.3 - 37.9)	0.001*	Ref				

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Married	40.3 (39.8 - 40.9)	42.6 (42.0 - 43.2)	46.7 (46.2 - 47.3)	47.4 (46.8 - 48.0)	< 0.001*	1.62 (1.52 - 1.72)	1.52 (1.43 - 1.61)	1.41 (1.34 - 1.48)	1.44 (1.37 - 1.51)	0.609*
Formerly married	38.6 (36.6 - 40.7)	40.8 (38.7 - 42.9)	51.3 (49.6 - 53.1)	47.8 (46.1 - 49.4)	0.070*	1.52 (1.36 - 1.69)	1.45 (1.30 - 1.61)	1.63 (1.49 - 1.78)	1.48 (1.36 - 1.60)	0.993*
Religion										
Buddhist	37.0 (36.5 - 37.5)	39.9 (39.3 - 40.4)	44.6 (44.2 - 45.1)	44.6 (44.2 - 45.1)	0.002*	Ref				
Non-Buddhist	36.7 (34.5 - 38.9)	35.1 (32.9 - 37.3)	45.8 (43.7 - 47.8)	43.9 (41.8 - 46.0)	0.066*	0.99 (0.89 - 1.10)	0.92 (0.82 - 1.03)	1.07 (0.97 - 1.17)	0.95 (0.87 - 1.05)	0.980*
Employment status										
Employed	40.7 (40.2 - 41.3)	43.2 (42.6 - 43.7)	48.0 (47.5 - 48.5)	48.8 (48.3 - 49.3)	< 0.001*	Ref				
Unemployed	18.9 (18.0 - 20.0)	23.0 (22.0 - 24.1)	28.2 (27.2 - 29.2)	26.9 (26.0 - 27.8)	< 0.001**	0.34 (0.31 - 0.36)	0.37 (0.35 - 0.39)	0.36 (0.34 - 0.39)	0.36 (0.34 - 0.38)	0.819*
Highest education level										
None	45.1 (42.3 - 47.9)	41.3 (38.5 - 44.1)	43.5 (41.3 - 45.6)	43.3 (41.9 - 44.8)	0.817*	Ref				

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Primary	40.1 (39.5 - 40.8)	41.8 (41.2 - 42.5)	44.9 (44.3 - 45.6)	45.6 (44.8 - 46.3)	< 0.001*	0.70 (0.62 - 0.79)	0.94 (0.83 - 1.07)	0.96 (0.87 - 1.05)	1.08 (1.01 - 1.15)	0.215*
Secondary	31.9 (31.0 - 32.8)	37.1 (36.2 - 38.0)	44.7 (43.8 - 45.5)	46.8 (46.0 - 47.6)	< 0.001*	0.59 (0.52 - 0.67)	0.88 (0.78 - 1.01)	1.01 (0.92 - 1.11)	1.13 (1.06 - 1.21)	0.060*
Higher education	28.8 (27.4 - 30.2)	35.6 (34.2 - 36.9)	44.0 (42.9 - 45.1)	40.2 (39.3 - 41.1)	< 0.001**	0.43 (0.38 - 0.50)	0.73 (0.63 - 0.84)	0.96 (0.86 - 1.06)	0.90 (0.84 - 0.97)	0.048**
Unspecified	33.1 (22.9 - 43.3)	34.9 (26.5 - 43.3)	73.1 (65.0 - 81.3)	62.3 (56.2 - 68.4)	0.083*	0.58 (0.35 - 0.93)	0.75 (0.50 - 1.11)	3.13 (2.04 - 4.90)	1.83 (1.40 - 2.41)	0.061**

Legend: CI = confidence interval; OR = odds ratio; ref = reference group; * = linear model; ** = quadratic model

Prevalence of meeting the sleep recommendation

In 2015, the prevalence of Thai adults who met the sleep recommendation was 56.4% (95% CI: 56.0, 56.9). For the overall sample and for most sociodemographic groups, the sample prevalence of adults meeting the sleep recommendation was lowest in 2001, rose to its highest in 2009, and then declined in 2015. However, an inverted U-shaped trend was found to be significant only in the overall sample, among Buddhists, and among those who had secondary or higher education.

Associations of sociodemographic characteristics with meeting the sleep recommendation

Females had 28%, 25%, 32%, and 35% higher odds of meeting the sleep recommendation than males in 2001, 2004, 2009, and 2015, respectively (Table 4). In most survey years, significantly higher odds of meeting the recommendation were found for the youngest adult group (compared to those aged 50-59 years), inhabitants of the North-East region (compared to those from Bangkok), married (compared to those who have never been married), and employed (compared to unemployed). Thai adults without formal education had the lowest odds of meeting the sleep recommendation.

Table 8. 4 Meeting the sleep guideline: population prevalence and associations with sociodemographic variables

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Total (*n*)	53.7 (53.2 - 54.2)	56.1 (55.6 - 56.6)	57.8 (57.4 - 58.3)	56.4 (56.0 - 56.9)	< 0.001**					
Sex										
Male	51.7 (51.0 - 52.4)	54.5 (53.7 - 55.2)	55.6 (55.0 - 56.3)	53.7 (53.0 - 54.3)	0.494*	Ref				
Female	55.7 (55.0 - 56.4)	57.8 (57.1 - 58.5)	60.0 (59.4 - 60.6)	59.0 (58.4 - 59.6)	0.085*	1.28 (1.22 - 1.33)	1.25 (1.20 - 1.30)	1.32 (1.27 - 1.37)	1.35 (1.30 - 1.40)	0.715*
Age										
18 - 29	53.8 (52.9 - 54.6)	56.2 (55.4 - 57.1)	58.0 (57.2 - 58.8)	54.6 (53.8 - 55.5)	0.798*	Ref				
30 - 39	56.4 (55.5 - 57.4)	56.9 (55.9 - 57.9)	59.6 (58.8 - 60.5)	58.3 (57.4 - 59.2)	0.181*	1.10 (1.03 - 1.16)	0.94 (0.88 - 0.99)	0.99 (0.94 - 1.05)	1.02 (0.96 - 1.07)	0.900*
40 - 49	53.9 (52.9 – 55.0)	56.6 (55.6 - 57.7)	57.6 (56.7 - 58.5)	58.4 (57.5 - 59.3)	0.002*	0.99 (0.94 - 1.06)	0.95 (0.89 - 1.01)	0.94 (0.89 - 0.99)	1.07 (1.01 - 1.13)	0.744*

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
50 - 59	48.0 (46.7 - 49.3)	53.9 (52.6 - 55.1)	55.5 (54.4 - 56.5)	54.2 (53.2 - 55.2)	0.182*	0.83 (0.77 - 0.89)	0.9 (0.84 - 0.97)	0.93 (0.88 - 0.99)	0.96 (0.91 - 1.03)	0.563*
Household area										
Urban	52.1 (51.2 - 53.0)	57.0 (56.1 - 57.8)	58.0 (57.2 - 58.8)	58.2 (57.5 - 58.9)	0.065*	Ref				
Rural	54.5 (53.9 - 55.1)	55.7 (55.1 - 56.3)	57.8 (57.2 - 58.3)	54.8 (54.2 - 55.4)	0.816*	1.01 (0.96 - 1.07)	0.97 (0.92 - 1.02)	0.97 (0.93 - 1.02)	0.91 (0.87 - 0.95)	0.647*
Region										
Bangkok	48.3 (46.9 - 49.8)	57.5 (56.1 - 58.8)	55.3 (53.9 - 56.7)	58.7 (57.5 - 59.8)	0.123*	Ref				
Central	54.9 (53.9 - 56.0)	55.6 (54.5 - 56.6)	59.4 (58.5 - 60.3)	57.4 (56.6 - 58.2)	0.212*	1.33 (1.23 - 1.44)	0.94 (0.87 - 1.01)	1.27 (1.17 - 1.37)	1.03 (0.96 - 1.09)	0.633*
North	57.0 (55.9 - 58.2)	56.0 (54.8 - 57.1)	56.8 (55.7 - 57.9)	54.8 (53.7 - 55.9)	0.103*	1.46 (1.34 - 1.59)	0.98 (0.90 - 1.07)	1.16 (1.07 - 1.26)	0.97 (0.90 - 1.04)	0.285*
North-East	55.5 (54.6 - 56.3)	58.0 (57.1 - 58.9)	60.3 (59.5 - 61.1)	57.7 (56.8 - 58.6)	0.434*	1.36 (1.25 - 1.47)	1.05 (0.97 - 1.14)	1.38 (1.27 - 1.49)	1.12 (1.04 - 1.20)	0.741*
South	46.7 (45.2 - 48.1)	51.0 (49.5 - 52.4)	52.5 (51.2 - 53.7)	51.1 (49.8 - 52.3)	0.220*	0.93 (0.85 - 1.02)	0.78 (0.71 - 0.86)	0.95 (0.87 - 1.04)	0.81 (0.75 - 0.87)	0.800*
Marital status										

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Never married	53.2 (52.2 - 54.2)	53.0 (52.0 - 54.0)	56.2 (55.2 - 57.1)	54.7 (53.9 - 55.6)	0.229*	Ref				
Married	54.2 (53.6 - 54.8)	57.6 (57.0 - 58.2)	58.8 (58.2 - 59.3)	57.5 (57.0 - 58.1)	0.250*	0.98 (0.93 - 1.04)	1.20 (1.13 - 1.27)	1.10 (1.04 - 1.16)	1.10 (1.05 - 1.15)	0.814*
Formerly married	49.9 (47.8 - 52.0)	52.1 (50.0 - 54.2)	54.0 (52.3 - 55.8)	53.2 (51.6 - 54.8)	0.101*	0.85 (0.77 - 0.94)	1.00 (0.90 - 1.11)	0.91 (0.84 - 0.99)	0.93 (0.85 – 1.00)	0.924*
Religion										
Buddhist	53.9 (53.3 - 54.4)	56.4 (55.9 - 56.9)	58.0 (57.6 - 58.5)	56.6 (56.1 - 57.0)	< 0.001**	Ref				
Non-Buddhist	50.7 (48.4 – 53.0)	51.2 (48.9 - 53.5)	54.2 (52.1 - 56.2)	53.3 (51.2 - 55.4)	0.070*	1.07 (0.97 - 1.19)	1.00 (0.90 - 1.11)	1.04 (0.95 - 1.14)	1.08 (0.98 - 1.18)	0.931*
Employment status										
Employed	55.1 (54.6 - 55.7)	58.2 (57.6 - 58.7)	60.1 (59.6 - 60.6)	58.8 (58.4 - 59.3)	0.149*	Ref				
Unemployed	46.9 (45.7 - 48.2)	46.6 (45.4 - 47.8)	47.0 (45.9 - 48.1)	46.1 (45.1 - 47.2)	0.353*	0.69 (0.65 - 0.73)	0.60 (0.56 - 0.63)	0.54 (0.51 - 0.57)	0.55 (0.53 - 0.58)	0.351*
Highest education level										

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
None	45.0 (42.2 - 47.8)	44.7 (41.9 - 47.5)	50.2 (48.0 - 52.3)	52.3 (50.9 - 53.8)	< 0.001*	Ref				
Primary	53.9 (53.3 - 54.5)	55.3 (54.6 - 56.0)	55.8 (55.1 - 56.4)	54.6 (53.8 - 55.3)	0.695*	1.41 (1.25 - 1.59)	1.40 (1.24 - 1.58)	1.14 (1.04 - 1.25)	1.05 (0.98 - 1.13)	0.261*
Secondary	54.0 (53.0 - 55.0)	57.1 (56.2 - 58.1)	59.4 (58.5 - 60.2)	56.6 (55.8 - 57.4)	< 0.001**	1.53 (1.35 - 1.73)	1.68 (1.48 - 1.90)	1.42 (1.29 - 1.56)	1.19 (1.11 - 1.27)	0.275*
Higher education	54.5 (52.9 – 56.0)	60.1 (58.7 - 61.5)	63.2 (62.1 - 64.2)	60.8 (59.9 - 61.8)	< 0.001**	1.48 (1.29 - 1.69)	1.73 (1.51 - 1.98)	1.67 (1.51 - 1.85)	1.43 (1.33 - 1.54)	0.740*
Unspecified	58.2 (47.5 - 68.9)	63.1 (54.5 - 71.6)	53.0 (43.8 - 62.2)	50.9 (44.6 - 57.2)	0.045*	1.92 (1.22 - 3.06)	2.02 (1.38 – 3.00)	1.07 (0.73 - 1.58)	0.86 (0.66 - 1.11)	0.091*

Legend: CI = confidence interval; OR = odds ratio; ref = reference group; * = linear model; ** = quadratic model

Prevalence of meeting all 24-hour movement guidelines

In 2015, the prevalence of Thai adults who met all 24-hour movement guidelines was 21.3% (95% CI: 20.9, 21.7). For the whole sample and for most sociodemographic groups, the sample prevalence rose from 2001 to its peak in 2009, and then declined in 2015. However, this inverted U-shaped trend was found to be significant only among females, those who were 30-39 years of age, residents of rural areas, inhabitants of the Central and North-East region, those who have never been married or who were formerly married, unemployed, and those who had secondary or higher education. The prevalence of meeting 24-hour guidelines showed significant incremental increase from 2001 to 2015 (*p*-value for linear trend < 0.05) among males, those aged 40-49 years, and those who lived in Bangkok or the South region.

Associations of sociodemographic characteristics with meeting the overall 24-hour movement guidelines

Females had 53%, 60%, 73%, and 43% higher odds of meeting the overall guidelines than males in 2001, 2004, 2009, and 2015, respectively (Table 5). Thai adults who lived in Bangkok had the lowest odds of meeting the overall guidelines, while those from the North region had the highest odds in all survey years except in 2009. In most survey years, significantly higher odds of meeting the overall guidelines were also found for those who were married or formerly married (compared to those who have never been married) and employed (compared to unemployed). An inverted U-shaped trend was found for the odds of meeting the guidelines for the higher education group, where the odds increased from 2001 to 2009 and then decreased in 2015 (p = 0.046).

Table 8. 5 Meeting the overall guidelines: population prevalence and associations with sociodemographic variables

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Total (*n*)	13.2 (12.9 - 13.5)	19.4 (19.0 - 19.8)	22.7 (22.3 - 23.0)	21.3 (20.9 - 21.7)	0.093*					
Sex										
Male	11.5 (11.0 - 11.9)	16.7 (16.2 - 17.3)	18.8 (18.3 - 19.3)	19.2 (18.7 - 19.8)	0.033*	Ref				
Female	14.9 (14.4 - 15.4)	22.1 (21.5 - 22.7)	26.4 (25.8 - 26.9)	23.3 (22.8 - 23.9)	< 0.001**	1.53 (1.44 - 1.63)	1.60 (1.51 - 1.69)	1.73 (1.65 - 1.81)	1.43 (1.36 - 1.50)	0.748*
Age										
18 - 29	11.4 (10.9 - 12.0)	17.9 (17.2 - 18.6)	20.0 (19.3 - 20.6)	17.9 (17.3 - 18.6)	0.219*	Ref				

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
30 - 39	14.7 (14.0 - 15.4)	20.8 (20.0 - 21.6)	25.7 (24.9 - 26.4)	23.7 (22.9 - 24.5)	< 0.001**	1.00 (0.92 - 1.09)	0.90 (0.84 - 0.97)	1.14 (1.07 - 1.22)	1.11 (1.03 - 1.18)	0.497*
40 - 49	14.7 (14.0 - 15.5)	20.4 (19.5 - 21.2)	23.1 (22.3 - 23.9)	23.2 (22.4 - 23.9)	0.034*	0.94 (0.86 - 1.03)	0.86 (0.79 - 0.93)	0.96 (0.90 - 1.03)	1.04 (0.97 - 1.12)	0.576*
50 - 59	12.4 (11.6 - 13.3)	18.9 (17.9 - 19.9)	22.1 (21.2 – 23.0)	20.7 (19.9 - 21.5)	0.100*	0.82 (0.74 - 0.91)	0.83 (0.75 - 0.90)	0.98 (0.91 - 1.06)	0.95 (0.88 - 1.03)	0.526*
Household area										
Urban	9.8 (9.3 - 10.3)	17.8 (17.2 - 18.5)	21.6 (20.9 - 22.2)	21.4 (20.8 - 21.9)	0.053*	Ref				
Rural	14.9 (14.4 - 15.3)	20.2 (19.7 - 20.7)	23.2 (22.7 - 23.6)	21.3 (20.7 - 21.8)	< 0.001**	1.19 (1.10 - 1.30)	0.95 (0.89 - 1.02)	0.95 (0.90 – 1.00)	0.94 (0.89 - 0.98)	0.471*
Region										
Bangkok	8.4 (7.6 - 9.2)	15.1 (14.1 - 16.1)	17.0 (16.0 - 18.1)	19.8 (18.9 - 20.8)	0.011*	Ref				
Central	11.3 (10.7 - 12.0)	18.4 (17.6 - 19.2)	22.7 (21.9 - 23.5)	21.3 (20.6 - 21.9)	< 0.001**	1.10 (0.96 - 1.26)	1.20 (1.08 - 1.33)	1.52 (1.39 - 1.68)	1.09 (1.01 - 1.18)	0.951*
North	16.3 (15.5 - 17.2)	23.8 (22.8 - 24.8)	24.4 (23.5 - 25.3)	22.9 (21.9 - 23.8)	0.288*	1.50 (1.30 - 1.73)	1.67 (1.49 - 1.86)	1.69 (1.52 - 1.87)	1.25 (1.14 - 1.36)	0.454*

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
North-East	15.0 (14.4 - 15.7)	20.7 (19.9 - 21.4)	24.5 (23.8 - 25.1)	21.7 (20.9 - 22.4)	< 0.001**	1.38 (1.21 - 1.59)	1.34 (1.21 - 1.49)	1.75 (1.59 - 1.93)	1.19 (1.10 - 1.29)	0.707*
South	11.6 (10.7 - 12.6)	16.4 (15.4 - 17.5)	20.2 (19.2 - 21.2)	20.6 (19.6 - 21.6)	0.010*	1.02 (0.87 - 1.20)	1.03 (0.91 - 1.17)	1.30 (1.16 - 1.45)	1.05 (0.96 - 1.16)	0.875*
Marital status										
Never married	8.2 (7.7 - 8.8)	12.9 (12.2 - 13.6)	17.0 (16.2 - 17.7)	16.6 (16.0 - 17.3)	< 0.001**	Ref				
Married	15.0 (14.6 - 15.5)	21.9 (21.4 - 22.4)	24.4 (23.9 - 24.8)	23.3 (22.8 - 23.7)	0.113*	1.49 (1.36 - 1.64)	1.65 (1.53 - 1.79)	1.38 (1.30 - 1.47)	1.34 (1.26 - 1.43)	0.509*
Formerly married	12.3 (11.0 - 13.7)	17.5 (15.9 - 19.1)	24.1 (22.6 - 25.6)	21.8 (20.5 - 23.2)	< 0.001**	1.17 (0.99 - 1.37)	1.25 (1.09 - 1.43)	1.31 (1.18 - 1.46)	1.23 (1.12 - 1.36)	0.905*
Religion										
Buddhist	13.1 (12.8 - 13.5)	19.6 (19.2 - 20.0)	22.7 (22.3 - 23.1)	21.3 (20.9 - 21.7)	0.103*	Ref				
Non-Buddhist	14.3 (12.7 - 15.9)	16.5 (14.8 - 18.2)	21.6 (19.9 - 23.3)	21.6 (19.8 - 23.3)	0.003*	1.16 (1.00 - 1.35)	1.00 (0.86 - 1.15)	1.12 (0.99 - 1.25)	1.11 (0.99 - 1.24)	0.976*
Employment status										

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Employed	15.0 (14.6 - 15.4)	21.8 (21.3 - 22.2)	25.0 (24.6 - 25.4)	24.0 (23.6 - 24.4)	0.079*	Ref				
Unemployed	4.8 (4.3 - 5.3)	8.3 (7.6 - 9.0)	11.1 (10.4 - 11.8)	10.0 (9.4 - 10.6)	< 0.001**	0.28 (0.25 - 0.32)	0.31 (0.28 - 0.34)	0.34 (0.31 - 0.37)	0.34 (0.31 - 0.36)	0.571*
Highest education level										
None	17.1 (15.0 - 19.2)	17.3 (15.1 - 19.4)	20.3 (18.6 - 22.1)	19.8 (18.6 - 20.9)	0.070*	Ref				
Primary	15.4 (14.9 - 15.8)	20.7 (20.1 - 21.2)	22.8 (22.2 - 23.3)	21.8 (21.2 - 22.4)	0.112*	0.84 (0.71 - 0.99)	1.16 (0.99 - 1.37)	1.01 (0.91 - 1.14)	1.06 (0.98 - 1.16)	0.701*
Secondary	9.8 (9.3 - 10.4)	17.7 (17.0 - 18.5)	22.2 (21.5 - 22.9)	21.5 (20.8 - 22.2)	< 0.001**	0.68 (0.57 - 0.81)	1.21 (1.03 - 1.44)	1.15 (1.02 - 1.29)	1.13 (1.04 - 1.23)	0.347*
Higher education	7.9 (7.1 - 8.7)	18.5 (17.4 - 19.6)	23.7 (22.7 - 24.6)	20.9 (20.1 - 21.6)	< 0.001**	0.47 (0.39 - 0.58)	1.13 (0.95 - 1.35)	1.26 (1.12 - 1.43)	1.15 (1.05 - 1.26)	0.046**
Unspecified	14.8 (7.1 - 22.5)	14.3 (8.1 - 20.5)	32.3 (23.7 - 40.9)	26.5 (20.9 – 32.0)	0.120*	1.10 (0.55 - 2.02)	0.92 (0.52 - 1.54)	1.82 (1.19 - 2.74)	1.31 (0.97 - 1.76)	0.639*

Legend: CI = confidence interval; OR = odds ratio; ref = reference group; * = linear model; ** = quadratic model

Discussion

The present study was the first to determine 15-year trends and sociodemographic correlates of meeting the new integrated 24-hour movement guidelines using nationally representative time-use data. We found that a vast majority of Thai adults met the MVPA recommendation, slightly above a half met the sleep recommendation, and slightly below a half met the SB recommendation. However, only one in five Thai adults met the overall 24-hour movement guidelines. An increasing number of Thai adults met the SB recommendation, while the prevalence of meeting the MVPA and sleep recommendations peaked in 2004 and 2009 and slightly declined in 2015. Employed adults were more likely to meet every recommendation (i.e., MVPA, MVPA for additional health benefits, SB, sleep, and overall 24-hour movement guidelines) compared to adults who are unemployed. Thai adults who were married were found to be more likely to meet the MVPA, SB, sleep, and overall 24-hour movement guidelines compared to those who have never been married. Thai females tended to meet the SB, sleep, and the overall guidelines more than males. However, we found that the percentage of males meeting the SB and overall guidelines increased over the 15 years. Education level seemed to play an important role in meeting the guidelines: those with no formal education were found to be the least likely to meet the MVPA, sleep, and MVPA recommendations for additional health benefits compared to other education groups. During the study period, the likelihood of meeting the overall 24-hour movement guidelines was found to increase significantly for the adults who had higher education.

Our findings confirm demographic trends in Thailand regarding age, household areas, and regions. Thailand has become an ageing society, due to declining birth rate and increasing life expectancy (59). The proportion of Thai people aged 60 and over increased over time; 4.8% in 1960, 10.5% in 2005, and 15.6% in 2015—and it was projected to reach 30.2% in 2035 (60). This is clearly reflected in the increasing proportion of older age groups in our study. The proportion of Thai adults living in urban areas has increased, which is in line with population and household census data (59). The capital city, Bangkok, and the Central region were the two regions with increasing population. This may be because more and more people migrate to work or live in the urban areas of Bangkok and their vicinity (59).

We found that around one in five Thai adults met the overall 24-hour movement guidelines (i.e., MVPA, SB, and sleep recommendations combined) in 2015. A recent study found that in the same year only 0.4% of Korean adults met a similar ‘ideal’ combination of movement behaviours (43). However, a direct comparison between these findings is not possible, as there are differences in methodology used to categorise participants. The overall 24-hour movement behaviour guideline in the Korean study included meeting MVPA (defined as ≥600 METs minute/week) and sleep (7 – 9 hours/day) recommendations and not having high sitting time (≥9 hours/day). Besides, Korean adults included in this study were between 18 and 64 years old, covering more of older age group than that in the current study.

The prevalence of Thai adults meeting the MVPA recommendation was very high in all survey years, even with a decrease in 2009 and 2015. National data collected using PA questionnaires, such as Global Physical Activity Questionnaire (GPAQ) and International Physical Activity Questionnaire (IPAQ), suggest similarly high prevalence rates; 77.5% in 2003, 74.9% in 2009, and 80.8% in 2015 (61). Our results for MVPA prevalence in the Thai population are concordant with previous findings mainly from low- and middle-income countries For example, the percentage of meeting MVPA recommendation in East and Southeast Asia increased from 74.3% in 2001 to 82.7% in 2016 (62). In some countries, such as Nepal (63), the prevalence of meeting MVPA recommendation was even higher than in Thailand. In studies that relied on data from PA questionnaires, such high prevalence rates may be a consequence of self-report bias. However, given that the questions in the Thai time-use survey did not ask specifically about PA levels, it is less likely that such bias have affected the results of our study.

The increasing MVPA in the Thai population found in the current study may be a positive result of national efforts to increase population PA. Important events for the promotion of PA in Thailand were the establishment of the Thai Health Promotion Foundation in 2001 and the Division of Physical Activity and Health, Ministry of Public Health in 2002 (64). These two organizations along with their network of alliances aim to improve the population PA by developing policies and implementing interventions. They have supported nationwide campaigns to promote PA and the development of the first national strategic plan on the promotion of PA (2018 – 2030) (65).

We found that urban residence in Thailand is associated with lower prevalence of MVPA. Evidence of such association was also found in other adult populations (43, 66-68). With increasingly evident changes in the population structure in Thailand, particularly migration of working adults to urban areas, continuing coordinated efforts are needed to prevent a potential decline in population PA. With changing nature of work, PA undertaken in occupational domain is also reduced. Future efforts are, therefore, needed to promote other types of PA particularly in transport and leisure-time domains.

Our results indicate significant differences in the likelihood of meeting the MVPA recommendation between sexes, age groups, household areas, employment status, and education levels. Consistent with previous studies, male sex, rural setting, employment, and higher education level were significant correlates of more MVPA (43, 66-68). However, in contrast to previous findings, older age groups in Thailand had higher PA than the youngest group. This finding adds to the mixed evidence of associations between younger age and higher PA (66, 69), and suggests that more PA promotion interventions might be needed among younger adults. Future intervention studies may consider exploring possible uses of emerging media and new technologies, which are increasing in popularity among young adults, to promote PA (70).

We found that more than a half of Thai adults do not interrupt their sedentary activities at least every two hours. It is encouraging that the number of Thai adults who meet the SB recommendation is increasing. This may be due to a rapid development of the body of evidence on detrimental effects of SB that occurred in the first half of the previous decade. The odds of meeting the SB recommendation were significantly higher among Thai females when compared with their male counterparts. This result supports the finding of a recent systematic review on SB correlates in Thailand that male adults engage more in SB than females (69). This result is, however, contradictory to the finding of a previous review that included studies from other countries (71). The reason for this difference may be that most previous evidence on this association came from high-income countries. Moreover, in accordance with existing literature, our study confirms that older age, being single, and being unemployed have positive associations with SB (71).

To our knowledge, this study is the first to examine the trends in meeting the sleep recommendation in Thai adults. Only about a half of Thai adults met the sleep recommendation. The prevalence of Thai adults meeting the sleep recommendation increased over the study period. In comparison, a declining trend was found in the American adult population from 2004 to 2012 (72), and no trends were observed among Danish adults between 2007 and 2010 (73). In 2015, the prevalence of meeting sleep recommendation among Thai adults was similar to that for Korean adults (43). This study explored sleep duration only, while sleep quality has not been examined. As there is limited information about trends in sleep among Thai adults, more studies are needed in this area, particularly including measures of different aspects of sleep quality.

Strengths and limitations

There are several strengths of the present study. First, this is the first study to examine the prevalence of meeting the Thai 24-hour movement recommendations. Second, a large sample size ensured adequate statistical power and sufficient precision in estimating population effect size. Third, this study showcases how to employ ICATUS-based data in PA and SB research. Last, we used time-use survey data which have been shown to provide reliable and valid estimates in large-scale studies (25).

This study had limitations. Firstly, ICATUS does not include a detailed breakdown of occupation- and travel-related activities according to their intensity level and posture. A more detailed assessment of these activities would allow for a more precise quantification of PA and SB levels. Using device-based measures of PA and SB might improve the accuracy of prevalence estimates. However, due to time and cost limitations, device-based measurements may be challenging to use for the assessment of PA and SB in large-scale studies, particularly in low- and middle-income countries (39, 74). Secondly, the Thai national time-use surveys were based on a one-day diary. Given that movement behaviours may vary across days of measurement, a longer measurement period would likely provide more reliable individual estimates. Finally, in this study we did not analyse domain-specific data on PA and SB (e.g. at work, in household, in transport, and in leisure-time). Such an additional analysis would provide even deeper understanding of patterns of these behaviours in the Thai population, but it was beyond the scope of this paper.

Conclusions

Despite promising trends in the prevalence of meeting PA, SB, and sleep recommendations, a large majority of Thai adults still do not meet the overall 24-hour movement guidelines. Further actions are needed to promote more MVPA, less SB, and adequate sleep in Thai adults, particularly among males, those living in urban areas, inhabitants of Bangkok and South Thailand, unemployed, and those with low education level. To be able to assess the effectiveness of such actions at the national level, it is critical to maintain regular nationwide surveillance and monitoring systems. Future studies should explore in more detail sleep quality and patterns of physical activity and sedentary behaviour in the Thai population. Moreover, since the 24-hour guidelines were only recently issued in Thailand, it is important to disseminate them, to ensure they reach as many people as possible.

List of abbreviations

- Akaike Information Criterion (AIC)
- American Time Use Survey (ATUS)
- Body Mass Index (BMI)
- Global Physical Activity Questionnaire (GPAQ)
- International Classification of Activities for Time-Use Statistics (ICATUS)
- International Physical Activity Questionnaire (IPAQ)
- International Standard Classification of Occupations (ISCO)
- Light Physical Activity (LPA)
- Metabolic Equivalents (METs)
- Moderate-to-Vigorous Physical Activity (MVPA)

- National Statistical Office (NSO)
- Physical Activity (PA)
- Restricted Maximum Likelihood Estimation (REML)
- Sedentary Behaviour (SB)
- Statistics Canada's General Social Survey – Time Use (GSS-TU)
- World Health Organization (WHO)

Additional Files

Additional File 1

> **File name:** Additional file 1_table of MVPA for additional health benefits.xlsx
>
> **Title:** Meeting the MVPA recommendation for additional health benefits
>
> **Description:** The prevalence and association table of MVPA for additional health benefits

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The prevalence and association of meeting the 24-hour guidelines are available in Tables and Supplementary material.

Competing interests

The authors declare no competing interests.

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Authors' contributions

NL and ZP conceived the idea for the study. NL, ZP, DD, MC, and SJHB conceptualised the study. NL, ZP and DD conceptualised the data analysis approach. NL conducted the harmonisation of ICATUS activities and analysed the datasets. NL drafted the manuscript. ZP, DD, MC, and SJHB contributed to writing the manuscript. All authors read and approved the final draft.

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CHAPTER IX: Thesis's Discussion, Conclusions, and Future directions

This chapter aims to conclude the study with a discussion about the main findings from five studies included in the thesis, followed by a description of strengths and limitations of the project. The main research conclusions are also presented, including directions and recommendations for future studies.

Discussion of Main Findings

In addition to a discussion of findings provided in each study (Chapter IV to Chapter VIII), this section discusses overall research findings and is divided into four sections, instead of by five papers. These sections include i) Prevalence and Trends of Physical Activity in Thailand; ii) Prevalence and Trends of Sedentary Behaviour in Thailand; iii) Correlates of Physical Activity in Thailand; and iv) Correlates of Sedentary Behaviour in Thailand. Findings on prevalence, trends, and correlates of physical activity (PA) and sedentary behaviour (SB) in the Thai population will provide a basis for determining the magnitude of PA and SB problems and understanding factors associated with the behaviours. Together, these aspects of PA and SB are essential to develop initiatives relevant and effective in the Thai context.

Prevalence and Trends of Physical Activity in Thailand

Research on the prevalence of PA has been conducted in the Thai context from sample sizes ranging from small to a national scale. Our scoping review showed 12.4% of 564 articles focused on the prevalence of PA and/or SB. However, the validity and reliability of the measurements used in the previous studies are of concern. This thesis addresses this gap in the literature by providing a prevalence estimate of PA and SB among Thai people aged 18 years and older, analysed from the largest and latest available survey using a validated tool, GPAQ (Bull, Maslin, & Armstrong, 2009). The 2015 Health and Welfare Survey is the most recent national survey with GPAQ integrated in the questionnaire. The prevalence, including data from 108,416 participants (representing more than 52 million Thai adults) showed that 42.4% of Thai younger and older adults met the MVPA recommendation (i.e., at least 600 METs per week) in 2015. This prevalence was higher in males than in females (49.2% vs. 36.2%, respectively). This suggests that more than 30 million Thai adults are not physically active enough, and are consequently at risk of developing chronic diseases. Other estimates based on Thai self-report data showed 71.6% - 80.8% of adults aged 15 years and older had sufficient MVPA (i.e., at least 150 minutes per week) in the same year (Division of Physical Activity & Health, 2015). This difference from the current study was likely due to inconsistent methodology used in these surveys. Our study included more than five to ten times as many participants (7,444 – 19,331 vs. 108,416). The age of participants included in the other surveys are 15 years and older which may contribute to higher accumulating PA levels (Bauman, Sallis, Dzewaltowski, & Owen, 2002; Trost, Owen, Bauman, Sallis, & Brown, 2002). Studies used different MVPA cut-points, which may have led to an inconsistencies in the estimates of the MVPA prevalence in Thai younger and older adults.

A wide variation in prevalence of MVPA level found within the country from traditional PA surveys also suggest the need for the improved measurement of PA behaviours. Time-use data seem to provide validated, comprehensive data which are less liable to recall bias than conventional PA questionnaire (Bauman, Bittman, & Gershuny, 2019; Chau, Gomersall, van der Ploeg, & Milton, 2019). Time-use data are also considered to be a more practical option for large-scale measurements of PA and SB than device-based tools, particularly in low- and middle-income countries (Harms, Berrigan, & Gershuny, 2019; Pedišić & Bauman, 2015). We, therefore, explored Thai national ICATUS-based surveys to examine PA and SB. Prior to the analysis, ICATUS-based activities had to be converted into PA, SB, and sleep categories. The transformation processes are explained in detail in Chapter VII.

Chapter VIII sought to determine the temporal trends of Thai adults aged between 18 and 59 years using the Thai national ICATUS-based time-use surveys. This study, for the first time, employed ICATUS-based time-use data, categorised into PA, SB, and sleep to assess trends in meeting the MVPA recommendation over time. These data provide a comprehensive examination of PA and SB levels and temporal trends in the behaviours among Thai adults. We found 81.7% of Thai adults met the MVPA recommendation (i.e., ≥150 minutes per week) in 2015. Between 2001 and 2004, the prevalence of sufficient levels of MVPA increased by almost 15 percentage points (from 73.2% to 88.1%). However, after 2004 the MVPA levels declined (from 88.1% in 2004, to 87.6% in 2009, and 81.7% in 2015). While the global trend of PA remained relatively stable between 71.5% in 2001 and 72.5% in 2016, Thailand and other countries in East and Southeast Asia had an increase of MVPA prevalence during the respective years (Guthold, Stevens, Riley, & Bull, 2018). Although, there was an increase of meeting the MVPA recommendation between 2001 and 2015, our results showed a decline of MVPA prevalence in the past decade. This trend may be explained by the establishment of important organizations responsible for PA promotion in early 2000s. However, the influences of increasing urbanisation in Thailand seem to have started to manifest as MVPA prevalence dropped (Bauman et al., 2012; Koyanagi, Stubbs, & Vancampfort, 2018a; Sallis et al., 2016; United Nations, 2018).

In summary, the low prevalence and declining trend of MVPA over time highlight the need of public health programs to promote PA in Thailand. Currently, Thailand adopts the first National

Strategic Plan on Promotion of Physical Activity (2018 – 2030) (Division of Physical Activity & Health, 2018). It is also important to scale up its implementation to reflect on a national impact.

Prevalence and Trends of Sedentary Behaviour in Thailand

In this thesis, the prevalence of SB in Thai adults aged 18 and older were also identified. However, the measurement of time spent sedentary was a challenge. Even though the GPAQ is considered a validated tool (Bull et al., 2009), with only one item on sitting time, participants are likely to underestimate their time spending sitting (Clemes, David, Zhao, Han, & Brown, 2012). Moreover, a lack of rigorous translation process of the instrument into Thai may adversely affect the results, especially at a population-based scale (Su & Parham, 2002). The prevalence of SB identified in Chapter V referred to participants who had no MVPA in all domains (i.e., occupation, transport, and leisure-time), and reported having sedentary time. The results showed that 33.8%, more than 17.7 million Thai younger and older adults had high SB in 2015 and are, therefore, at risk of detrimental effects on their health. This prevalence was higher in females than males (37.4% vs. 29.9%, respectively). Although a large body of research have shown the associations of SB with negative health consequences, the evidence on the amount of SB is not clear (Stamatakis et al., 2019). Some meta-analyses have proposed that 7 hours of SB a day might be a threshold for increased mortality risk (Chau et al., 2013; Ku, Steptoe, Liao, Hsueh, & Chen, 2018), while another study suggests a 4 hours/day threshold (Ekelund et al., 2016). Another meta-analysis also indicates fewer than 9 hours per day of SB measured by device-based tools is associated with increased all-cause mortality risk (Ku et al., 2018). With insufficient evidence to provide specific limit of daily SB, public health guidelines of several countries including Thailand use SB interruptions as a recommendation to reduce SB in a population (Khamput et al., 2017; Stamatakis et al., 2019).

Breaking up time spent in SB is linked with improved cardio-metabolic health (Healy et al., 2008). In the case of Thailand guidelines, it is recommended that adults should avoid prolonged sitting while working and break sedentary time every two hours (Khamput et al., 2017). The findings in Chapter VIII showed temporal trends of meeting this SB recommendation among adults aged 18 – 59 years using the Thai national ICATUS-based time-use surveys. The findings revealed a significant linear trend of Thai adults who met the recommendation over the 15 years period. The favourable rates increased from 36.9% in 2001, to 39.6% in 2004, to 44.7% in 2009, and relatively remained stable at 44.6% in 2015. This may imply that the population’s total sedentary time has decreased and/or prolonged sitting time was interrupted among Thai adults. These results are contradictory to those found in earlier epidemiological studies. For example, a multinational study including the United States, the United Kingdom, Brazil, China, and India (representing almost 50% of the world’s population) showed an upward trend of SB over the long term (Ng & Popkin, 2012). However, overall trends are not clear. Another epidemiological study of 27 countries within the European region found self-reported sedentary time remained constant at around 5 hours a day between 2002 and 2013 (Milton, Gale, Stamatakis, & Bauman, 2015). Similarly to the Australian study of total non-occupational sedentary time also showed stable trends at around 7.5 hours per day between 1997 and 2006 (Chau et al., 2012).

In summary, although Thai adults seemed to be aware of breaking up their sedentary time, their rate of SB interruptions remained relatively constant between the last two survey years, and thus these increasing trends might not continue over time. Moreover, even we found a favourable trend, more than half of Thai adults still engaged in prolonged sitting with no breaks. Therefore, promoting less prolonged, uninterrupted SB at the population level is needed.

Correlates of Physical Activity in Thailand

The scoping review presented in Chapter IV, demonstrated that most of the evidence currently available is on the association (or correlates) of regular PA. This evidence provides an opportunity to summarise key associations of PA and thus provide a stronger evidence base to support the development of public health interventions. This thesis includes three studies (Chapter V, VI, and VIII) that examined correlates of PA and SB. The main findings of each study were discussed in depth in each chapter. To avoid repetitions, only important variables that can be summarised from these three studies are discussed here.

Differences in Physical Activity According to Gender and Age

The results of this thesis provide further evidence for literature on associations between PA and gender and age. Our results show consistent findings for the associations of higher PA with male sex and younger age in children and adolescents. Our systematic review provides further evidence that PA declines with age, and boys are more physically active than girls. These findings are concordant with other studies internationally and nationally (Amornsriwatanakul et al., 2016; Hallal et al., 2012; Telford, Telford, Olive, Cochrane, & Davey, 2016; Trost, Pate, et al., 2002). However, for Thai younger and older adults, gender- and age-based differences in PA show inconsistent results. Male gender and younger age have been identified as the two most consistent factors associated with high PA (Bauman et al., 2012). However, inconclusive findings on associations between these factors and PA were reported, when examined specifically in the context of low- and middle-income countries (Sallis et al., 2016).

In Chapter VI, inconsistent evidence for the associations of male gender and younger age was found. In Chapters V and VIII, these two variables accounted for higher PA when included older adults in the study. When analysed only Thai working-aged adults (aged 18 – 59 years), males were not significantly more active than females, while older age groups had significantly higher PA than the youngest adults. These results may indicate that middle-aged adults (i.e., 30 – 59 years of age) were the most physically active group compared to youngest and older adults.

There is mixed evidence on gender-based discrepancy in PA from previous studies. According to the global estimates in 2016, male sex was a significant correlate of higher PA except in East and Southeast Asia (Guthold et al., 2018). This is supported by a recent systematic review showing that sex was an inconsistent correlate of PA among adults from Southeast Asian countries (Abadini, Adriani, & Wuryaningsih, 2018). Another systematic review; however, found males were more physically active than females in 46 low- and middle-income countries (Koyanagi et al., 2018a). Country-specific studies are, therefore, needed to provide relevant findings which lead to practical public health implications. Findings of this doctoral research suggests that further actions to promote PA should focus particularly on girls, older women and young adults of both sexes.

Differences in Physical Activity According to Education Level and Urban/Rural setting

This thesis highlights the importance of investigating how correlates of PA have changed over time from different years of surveys. Our results support the negative associations between PA and education level and urban setting. The education level has shown correlation with populations' PA in previous studies (Bauman et al., 2012). Our prevalence estimates showed that Thai adults with high education had a significantly high PA in 2015, similarly to several countries, mostly from high-income economies (Trost, Owen, et al., 2002). However, the analyses to examine changes between 2001 and 2015 showed that high education level was associated with low PA in 2001, which is similar to previous findings for low- and middle-income countries (Koyanagi et al., 2018a). This indicates that PA correlates can change over time, and thus ongoing investigation of PA correlates is important, to timely inform PA strategies and interventions.

From current findings, high education level was associated with lower PA in 2001 and with higher PA in subsequent survey years. This trend analysis may suggest that some PA promotion programs/campaigns that were implemented at the population level in Thailand over the years have been effective among adults with higher levels of education. For example, running marathons is one of the most popular campaigns in Thailand that have been organised and received more attention country-wide in the past several years. Campaigns to increase PA in leisure-time are more effective in adults with high education compared to the lower levels

(Topothai et al., 2017). Therefore, the development of effective interventions focusing on different socioeconomic groups and/or domains such as work and transport is also needed.

Previous studies show that Thai adults who have no formal education mostly perform PA through work, which is the largest domain of PA among Thai adults and other countries (Csizmadi, Siou, Friedenreich, Owen, & Robson, 2011; Nang et al., 2010; Ng, Norton, & Popkin, 2009; Topothai et al., 2017). Consequently, lower levels of PA in this group may reflect changes in the level of PA undertaken in the work domain. This may be attributable, in part, to rapid urbanisation in Thailand (United Nations, 2018), where manual labour is likely to be reduced.

Our findings also support association between lower PA and living in urban settings. Consistent with a multi-country study of 46 low- and middle-income countries, urban environments have contributed to lower PA (Koyanagi et al., 2018a). Although the proportion of residency and PA prevalence among Thai adults are still higher in rural than urban areas, our trend analyses showed that the prevalence of rural inhabitants who have sufficient PA decreased over the 15-year period. This may indicate a greater need for PA promotion in this particular subgroup. In addition, as increasing numbers of Thai adults live in urban settings, a decreasing trend of PA in rural areas may be due in part to high rural-to-urban migration in Thailand. Therefore, national policy should be implemented to increase more PA participation, in both urban and rural settings. For example, improved public transportation to encourage people to commute actively to work, increasing public green spaces to create more opportunities for PA in local communities, and promoting active programs regularly available in workplaces.

Correlates of Sedentary Behaviour in Thailand

Our studies examined correlates of meeting the SB recommendation (i.e., interrupting SB every two hours) and high SB (i.e., having SB, and no MVPA in any domains), and summarised evidence on SB associations from 40 studies conducted in the Thai population (Chapters V, VI, and VIII). Based on these studies, there are important variables that show significant associations with SB among Thai adults; namely, age, gender, and level of education. The findings of a positive association between older age and SB are consistent with previous studies (Bennie et al., 2013; Koyanagi, Stubbs, & Vancampfort, 2018b; O’donoghue et al., 2016). This finding is critical not only for Thailand, but also worldwide, as many countries have encountered population ageing (National Statistical Office, 2011; United Nations, 2014). With low prevalence rates of meeting the SB recommendation, reducing SB in a population should be an important public health objective.

The differential prevalence of SB in male (vs. female) are also highlighted in this thesis. Several studies have shown that male adults tend to be more sedentary overall, particularly those from Western countries (Bennie et al., 2013; Kozo et al., 2012; Van Dyck et al., 2010). Our studies and others also found a significant association between male gender and high SB in middle-income countries (i.e., India, South Africa, and Thailand) (Koyanagi et al., 2018b). However, some studies found female sex to be related to high sitting and TV viewing time, while male gender was found to be associated with high computer use, overall leisure-time sitting, and transport SB (Koyanagi et al., 2018b). These findings suggest that further exploration across different domains (i.e., occupation, transport, and leisure-time) are warranted to give a better understanding of gender differences in SB among Thai adults. Another consistent factor associated with high SB in our studies and others is higher levels of education (Bennie et al., 2013; Kozo et al., 2012; Van Dyck et al., 2010). This correlation also emphasises the need of domain-specific studies to explore SB research. Sitting time at work can largely contribute to SB in the working population. The type of work determines how much time workers sit at their workplace (Thorp et al., 2012), and higher level of education may be an important mediator of the association between sitting-based jobs with higher overall SB.

Our studies identify adults who are males, older, and have higher levels of education as factors that appear to be related to SB in Thailand. Additionally, our findings of periodical studies provide novel findings on changes in these factors over time. Even though these population subgroups were less likely to meet the SB recommendation than their counterparts, the prevalence rates of their meeting the recommendation significantly increased over time. This means that the importance of older age, male gender, and higher levels of education in influencing SB have decreased. Therefore, trend studies provide important data to periodically examine the magnitude of the behaviour and its correlates. Trend studies should be continued to see if these trends persist and forecast the projections, if possible. In summary, research on correlates of SB in Thailand is still in its early stages. There is increasing, but still modest evidence on these correlations. More research is needed to understand factors of higher SB in Thailand especially at social, environmental, and policy-related levels. Further, as SB can take place throughout people’s waking hours, domain-specific analyses are also required.

Strengths and Limitations of the Thesis

There are important strengths of this doctoral research. First, this thesis used a transparent and rigorous approach in the scoping review and in the systematic review and included a comprehensive examination of PA and SB studies in the analyses. Second, a standardised Delphi process was utilised to develop the first expert-based classification of ICATUS activities into PA, SB, and sleep categories. This classification can be further adopted for greater application of time-use data and comparison studies in public health areas. Third, this PhD included analyses of data from large, population-representative samples to ensure sufficient generalisation and significant findings. Lastly, this thesis provides pioneering studies that can be used as examples of how to employ ICATUS-based data in PA and SB research. The thesis also demonstrates the applicability and advantages of utilising time-use data to examine the integrative 24-hour guidelines, which are likely to be adopted in more countries in the future.

There are also some inherent limitations in the methodology employed in this research. First, even though thorough search strategies were used to identify PA and SB studies in Thailand, it is possible that some relevant studies were not indexed in the databases that were used for the primary and secondary searches. Second, the cross-sectional design of the present work did not allow for causal interpretation of the studied associations. Third, the findings from this thesis were based on self-report data, which might be influenced by recall biases. However, these report biases might be somewhat reduced since we used time-use data, which record consecutive and continuous activities across 24-hour day (Adams et al., 2005; van der Ploeg et al., 2010). Fourth, time-use data do not provide a detailed assessment of tasks performed in working and traveling time. The assignments of precise quantifications representing intensity of PA and SB levels for occupational and travel-related activities were unavoidably simplified and should be interpreted with caution. Finally, the Thai national time-use surveys collected a single-day 24-hour diary information. A longer assessment period would provide a better representation of PA and SB estimates. However, most time-use surveys contain only one or two diary days, and are conducted at a population-representative level, this may even up some misclassifications caused by relatively short period of measurements (van der Ploeg et al., 2010).

Conclusions

PA and SB are important national and international health priorities. Research on PA and SB in Thailand has evolved and shown increasing rates in the past two decades. This provides a potential for a solid research base to support the development of interventions to promote healthy movement behaviours in the Thai population. However, there are research areas that need improvements to strengthen current country-specific evidence. In addition, findings from this thesis emphasise the persistent concerns about the impacts of declining PA level and high prevalence of SB among Thai adults. Although the magnitude of the problems was not as high as in some high-income countries (Guthold et al., 2018), a decline of activity rates and a high proportion of prolonged sitting in the population have important health implications.

This present work provides important implications for targeting future interventions and policy to increase PA levels in girls, older women, young adults, urban residents, and those with low education. Interventions may also consider developing programs that help improve self-efficacy for PA and lower perceived barriers for PA in the population across all age groups. SB reduction programs for adults should focus on male, older age groups, obese, and those with higher education. However, more studies are needed to provide a more complete picture of what factors are influencing PA and SB in the population; particularly among children, adolescents, older adults and at social, environmental and policy-related levels.

Although a large and growing evidence of literature have been identified in the current work, more research preferably with improved measures of PA and SB is needed to assess prevalence, trends and correlates of the behaviours. Device-based measures may provide more accurate estimates of the behaviours, but are still often unaffordable in population-level health surveillance. Research in Thailand and many other low- and middle-income countries have to rely on self-report measures of PA and SB, because of their cost-effectiveness and simplicity. This doctoral research, therefore, explored the potential of time-use survey data as they are considered to provide as accurate estimation of PA and SB as accelerometer-based data. A classification of ICATUS activities into PA, SB, and sleep categories was developed. This PhD work applied this classification to explore the utilisation of ICATUS-based data to monitor important patterns and associations of comprehensive movement behaviours. This thesis suggests that time-use data open possibilities to utilise national time-use surveys which are available in several countries around the world. This is particularly important, considering emerging evidence on the combined effects of the composition of movement behaviours across 24-hour day on health.

Future directions and recommendations

Based on findings from the present research, it is recommended that future studies place more focus on SB. Research concerning SB has emerged in the last two decades (Owen, Healy, Matthews, & Dunstan, 2010). Although, the amount of SB research has risen in Thailand and rapidly grown worldwide in the last decade (Stamatakis et al., 2019), the evidence base on SB is still underdeveloped compared to PA. This is not only evident in Thailand, but also in other regions such as the Arabian Peninsula (Mabry, Koohsari, Bull, & Owen, 2016). Moreover, it is highly recommended that future studies use an integrative approach that examines PA, SB, and sleep as a combined composition (Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015; Dorothea Dumuid, Tyman E Stanford, et al., 2018; Pedišić, Dumuid, & S Olds, 2017), which will also increase epidemiological evidence of SB.

According to the behavioural epidemiological framework, the development of accurate instruments to assess PA and SB is a priority (Owen et al., 2010). A high quality of measurement is required to quantify patterns and changes of the behaviours. The lack of a valid and reliable assessment of PA and SB in the Thai population is one of the main concerns outlined from the current work. It is, therefore, important for future studies to address this gap by providing validity evidence and assessing relevance in the cultures of influence. As previous studies relied excessively on non-validated self-report measures and tools, it is suggested that future studies use standardised self-report or device-based measures, if possible. For future SB prevalence and surveillance studies, it is indicative that a more detailed questionnaire, rather than a single item question may be required for more accurate estimates. In addition, as time-use surveys have been explored in the Thai context and the classification of ICATUS activities was developed, important next steps are to assess the validity and reliability of the classification and its estimates of PA and SB, compared to existing PA questionnaires and/or device-based instruments.

Like other health behaviours, PA and SB are influenced at multiple levels including individual, social, physical environment, and policy. However, current evidence shows that these associations were not well explored, as most studies only focused on the individual level. Therefore focus is needed on contributors at other levels (i.e., social, environment, and policy). In addition, most association studies used a cross-sectional design which cannot infer to causes and their respective outcomes. This indicates the need of longitudinal studies to identify determinants of PA and SB. Understanding determinants is another step leading to the development of feasible interventions.

Given the consideration of PA, SB, and sleep across 24-hour periods, more and more PA and SB research is using statistical methods that acknowledge the compositional nature of time-use data (Chastin et al., 2015; Dorothea Dumuid, Tyman E Stanford, et al., 2018; Pedišić, 2014; Pedišić et al., 2017). Time-use survey data can support research using the compositional data analysis, which acknowledges compositional properties of movement-related time-use components. To date, several studies have applied the compositional data analysis approach to examine movement behaviours. However, most of them have been conducted in high-income countries and using accelerometer-based data (Carson, Tremblay, Chaput, & Chastin, 2016; Carson, Tremblay, & Chastin, 2017; Chastin et al., 2015; Compernolle et al., 2018; D Dumuid et al., 2018; Dorothea Dumuid, Tyman E. Stanford, et al., 2018; Dumuid et al., 2019; Fairclough et al., 2018; Fairclough et al., 2017; Gupta et al., 2019; Gupta et al., 2018; Duncan McGregor et al., 2018; DE McGregor, Palarea-Albaladejo, Dall, Stamatakis, & Chastin, 2019; Rodríguez-Gómez et al., 2018; Talarico & Janssen, 2018). Very few studies on PA and SB have applied the new integrative concept in low- and middle-income countries (Dorothea Dumuid, Carol Maher, et al., 2018; Dumuid et al., 2017; Štefelová et al., 2018). Future studies should consider these methodological advances when exploring correlates and outcomes of PA and SB. Besides, compositional data analysis has never been used on PA and SB data derived from time-use surveys. Time-use survey data have been collected in more than 85 countries around the World and since 1960s (United Nations Statistics Division, 2018), and may provide a great platform for such analyses.

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APPENDICES

Appendix I: Search Keywords

Appendix I Search Keywords

Search keywords used for physical activity and sedentary behaviour:

- *"physical activity"*
- *"physical inactivity"*
- *"physically inactive"*
- *“physical fitness”*
- *"energy expenditure"*
- *Exercise*
- *Sport*
- *Gym*
- *"motor activity"*
- *Walking*
- *Cycling*
- *Stair**
- *“active travel”*
- *“active transport”*
- *sedentar**
- *sitting*
- *"watching TV"*
- *"TV watching"*
- *"TV viewing"*
- *Television*
- *"video watching"*
- *"watching video"*
- *"computer use"*
- *"internet use"*
- *Gaming*
- *"video games"*
- *"social media"*
- *"screen time"*
- *Lifestyle*
- *"strength training"*
- *"resistance training"*
- *"weight training"*

- *"weight lifting"*
- *"muscle strengthening"*
- *"muscular strengthening"*
- *"muscle training"*
- *"muscle toning"*
- *"weight bearing training"*
- *"weight bearing strengthening"*
- *"strength or toning"*
- *"strength/toning"*
- *"strength / toning"*
- *"strength and toning"*

These keywords were combined with the following keyword for Thailand setting:

- *thai**

Search Syntaxes:

Scopus:

title-abs-key("physical activity" OR "physical inactivity" OR "physically inactive" OR “physical fitness” OR "energy expenditure" OR exercise OR sport OR gym OR "motor activity" OR walking OR cycling OR stair OR “active travel” OR “active transport” OR sedentar* OR sitting OR "watching TV" OR "TV watching" OR "TV viewing" OR television OR "video watching" OR "watching video" OR "computer use" OR "internet use" OR gaming OR "video games" OR "social media" OR "screen time" OR lifestyle OR "strength training" OR "resistance training" OR "weight training" OR "weight lifting" OR "muscle strengthening" OR "muscular strengthening" OR "muscle training" OR "muscle toning" OR "weight bearing training" OR "weight bearing strengthening" OR "strength or toning" OR "strength/toning" OR "strength / toning" OR "strength and toning") AND title-abs-key(thai*)*

Pubmed

((("physical activity"[Title/Abstract] OR "physical inactivity"[Title/Abstract] OR "physically inactive"[Title/Abstract] OR “physical fitness” [Title/Abstract] OR "energy expenditure"[Title/Abstract] OR exercise[Title/Abstract] OR sport[Title/Abstract] OR gym[Title/Abstract] OR "motor activity"[Title/Abstract] OR walking[Title/Abstract] OR cycling[Title/Abstract] OR stair[Title/Abstract] OR “active travel”[Title/Abstract] OR “active transport”[Title/Abstract] OR sedentar*[Title/Abstract] OR sitting[Title/Abstract] OR "watching*

TV"[Title/Abstract] OR "TV watching"[Title/Abstract] OR "TV viewing"[Title/Abstract] OR television[Title/Abstract] OR "video watching"[Title/Abstract] OR "watching video"[Title/Abstract] OR "computer use"[Title/Abstract] OR "internet use"[Title/Abstract] OR gaming[Title/Abstract] OR "video games"[Title/Abstract] OR "social media"[Title/Abstract] OR "screen time"[Title/Abstract] OR lifestyle[Title/Abstract] OR "strength training"[Title/Abstract] OR "resistance training"[Title/Abstract] OR "weight training"[Title/Abstract] OR "weight lifting"[Title/Abstract] OR "muscle strengthening"[Title/Abstract] OR "muscular strengthening"[Title/Abstract] OR "muscle training"[Title/Abstract] OR "muscle toning"[Title/Abstract] OR "weight bearing training"[Title/Abstract] OR "weight bearing strengthening"[Title/Abstract] OR "strength or toning"[Title/Abstract] OR "strength/toning"[Title/Abstract] OR "strength / toning"[Title/Abstract] OR "strength and toning"[Title/Abstract]) OR ("physical activity"[MeSH Terms] OR "physical inactivity"[MeSH Terms] OR "physically inactive"[MeSH Terms] OR "energy expenditure"[MeSH Terms] OR exercise[MeSH Terms] OR sport[MeSH Terms] OR "motor activity"[MeSH Terms] OR sedentar[MeSH Terms] OR sitting[MeSH Terms] OR "watching TV"[MeSH Terms] OR "TV watching"[MeSH Terms] OR "TV viewing"[MeSH Terms] OR television[MeSH Terms] OR "video watching"[MeSH Terms] OR "watching video"[MeSH Terms] OR "computer use"[MeSH Terms] OR "internet use"[MeSH Terms] OR gaming[MeSH Terms] OR "video games"[MeSH Terms] OR "social media"[MeSH Terms] OR "screen time"[MeSH Terms] OR lifestyle[MeSH Terms] OR "strength training"[MeSH Terms] OR "resistance training"[MeSH Terms] OR "weight training"[MeSH Terms] OR "weight lifting"[MeSH Terms] OR "muscle strengthening"[MeSH Terms] OR "muscular strengthening"[MeSH Terms] OR "muscle training"[MeSH Terms] OR "muscle toning"[MeSH Terms] OR "weight bearing training"[MeSH Terms] OR "weight bearing strengthening"[MeSH Terms] OR "strength or toning"[MeSH Terms] OR "strength/toning"[MeSH Terms] OR "strength / toning"[MeSH Terms] OR "strength and toning"[MeSH Terms]) OR ("physical activity"[Other Term] OR "physical inactivity"[Other Term] OR "physically inactive"[Other Term] OR "energy expenditure"[Other Term] OR exercise[Other Term] OR sport[Other Term] OR "motor activity"[Other Term] OR sedentar*[Other Term] OR sitting[Other Term] OR "watching TV"[Other Term] OR "TV watching"[Other Term] OR "TV viewing"[Other Term] OR television[Other Term] OR "video watching"[Other Term] OR "watching video"[Other Term] OR "computer use"[Other Term] OR "internet use"[Other Term] OR gaming[Other Term] OR "video games"[Other Term] OR "social media"[Other Term] OR "screen time"[Other Term] OR lifestyle[Other Term] OR "strength training"[Other Term] OR "resistance training"[Other Term] OR "weight training"[Other Term] OR "weight lifting"[Other Term] OR "muscle strengthening"[Other Term] OR "muscular strengthening"[Other Term] OR "muscle training"[Other Term] OR "muscle toning"[Other Term] OR "weight bearing training"[Other Term] OR "weight bearing strengthening"[Other*

Term] OR "strength or toning"[Other Term] OR "strength/toning"[Other Term] OR "strength / toning"[Other Term] OR "strength and toning"[Other Term])) AND ((thai[Title/Abstract]) OR (thai*[MeSH Terms]) OR (thai*[Other Term])))*

Web of Science

("physical activity" OR "physical inactivity" OR "physically inactive" OR "physical fitness" OR "energy expenditure" OR exercise OR sport OR gym OR "motor activity" OR walking OR cycling OR stair OR "active travel" OR "active transport" OR sedentar* OR sitting OR "watching TV" OR "TV watching" OR "TV viewing" OR television OR "video watching" OR "watching video" OR "computer use" OR "internet use" OR gaming OR "video games" OR "social media" OR "screen time" OR lifestyle OR "strength training" OR "resistance training" OR "weight training" OR "weight lifting" OR "muscle strengthening" OR "muscular strengthening" OR "muscle training" OR "muscle toning" OR "weight bearing training" OR "weight bearing strengthening" OR "strength or toning" OR "strength/toning" OR "strength / toning" OR "strength and toning") AND thai**

Other databases (through EBSCOhost)

("physical activity" OR "physical inactivity" OR "physically inactive" OR “physical fitness” OR "energy expenditure" OR exercise OR sport OR gym OR "motor activity" OR walking OR cycling OR stair OR “active travel” OR “active transport” OR sedentar* OR sitting OR "watching TV" OR "TV watching" OR "TV viewing" OR television OR "video watching" OR "watching video" OR "computer use" OR "internet use" OR gaming OR "video games" OR "social media" OR "screen time" OR lifestyle OR "strength training" OR "resistance training" OR "weight training" OR "weight lifting" OR "muscle strengthening" OR "muscular strengthening" OR "muscle training" OR "muscle toning" OR "weight bearing training" OR "weight bearing strengthening" OR "strength or toning" OR "strength/toning" OR "strength / toning" OR "strength and toning") AND thai**

Appendix II: PRISMA

Appendix II PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	7-8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6-7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6-7
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7-8 and Figure 1
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8-10

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Additional file 1
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	10 and Additional file 3
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Not applicable
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8-10
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	10 and Additional file 3
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	10
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	11 and Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	11-12
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	12-13 and Additional file 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	13-34 and Additional file 2
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Table 2-7
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	12-13 and Additional file 3
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	12-13 and Additional file 3

DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	34-41
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	41-43
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	44-45
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	47

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

Appendix III: NOS Assessment

Appendix III Quality Assessment Using the Newcastle-Ottawa Scale

Results of the study quality assessment using the Newcastle-Ottawa Scale for cross-sectional studies

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
1	Ahmed, S. M., et al. (2009)	*	*	*	**	-	**	*	8
2	Akkayagorn, L., et al. (2009)	-	-	-	*	-	**	*	4
3	Amini, M., et al. (2009)	*	-	-	*	-	*	*	4
4	Amnatsatsue, K. (2002)	-	-	-	**	-	**	*	5
5	Angkurawaranon, C., et al. (2015)	-	-	-	*	**	*	*	5
6	A-piwong Chalong (2011)	-	*	-	**	-	*	*	5
7	Aree-Ue Suparb & Monrudee Petlamul (2013)	*	-	-	*	-	*	*	4
8	Ar-Yuwat, S., et al. (2013)	*	*	-	**	-	*	*	6
9	Asawachaisuwikrom Wannipa (2003)	*	*	-	**	-	*	*	6
10	Asawachaisuwikrom, W. (2004)	*	*	-	**	-	*	*	6
11	Assantachai, P. and N. Maranetra (2003)	*	*	-	**	-	*	*	6
12	Assantachai, P., et al. (2006)	*	-	-	*	-	**	*	5
13	Atchara, P., et al. (2014)	-	-	*	**	-	*	*	5
14	Aungsusuknarumol Chaiya (2000)	*	*	-	**	-	*	*	6

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
15	Baiya, N., et al. (2014)	-	*	*	*	-	*	*	5
16	Banks, E., et al. (2011)	*	*	*	**	**	*	*	9
17	Banwell, C., et al. (2009)	*	*	*	*	-	*	*	6
18	Binhosen, V., et al. (2003)	*	*	*	**	*	*	*	8
19	Boonrin et al (2015)	*	*	-	*	-	*	*	5
20	Charoensook Kiattisak (2007)	*	*	-	**	-	*	*	6
21	Charoenying et al (2006)	*	-	-	**	-	*	*	5
22	Chawla N. and Panza A. (2012)	*	-	-	**	-	**	*	6
23	Chinuntuya Prapaporn (2001)	*	*	-	**	-	*	*	6
24	Chompaisal S. (1994)	*	-	-	*	**	*	*	6
25	Chongwatpol, P. and G. E. Gates (2016)	-	-	-	**	-	*	*	4
26	Chotikacharoensuk, P. (2002)	*	*	-	**	-	*	*	6
27	Chuamoor, K., et al (2012)	-	-	*	*	-	*	*	4
28	Churangsarit, S. and V. Chongsuvivatwong (2011)	*	*	*	**	-	*	*	7
29	Dajpratham, P. and N. Chadchavalpanichaya (2007)	*	*	*	*	-	*	*	6
30	Dancy, C., et al. (2008)	-	-	-	**	**	**	*	7

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
31	Daraha, K. (2013)	*	-	-	*	-	*	*	4
32	Dasa Parinya (2001)	*	*	*	**	-	*	*	7
33	Decharat, S., et al. (2016)	-	-	-	*	-	*	*	3
34	Deenan et al (2001)	*	-	*	**	-	**	*	7
35	Ekpanyaskul, C., et al (2013)	*	*	*	*	-	*	*	6
36	Ethisan et al (2016)	-	-	-	**	-	*	*	4
37	Gidlof L. and Belay H.R. (2010)	*	-	-	-	-	*	*	3
38	Henry, C. J., et al. (2001)	-	-	-	**	-	*	*	4
39	Howteerakul, N., et al. (2006)	*	*	-	*	**	**	*	8
40	Ing-Arahm, R., et al. (2010)	-	-	*	**	-	*	*	5
41	Insawang, T., et al. (2012)	-	-	*	**	**	**	*	8
42	Intorn, S. (2003)	*	*	-	**	-	*	*	6
43	Ishimaru, T. and S. Arphorn (2016)	-	-	*	*	**	**	*	7
44	Jarupanich, T. (2007)	-	-	-	*	-	**	*	4
45	Jaruratanasirikul, S., et al. (2009)	*	-	*	**	-	*	*	6
46	Jermsuravong et al (2008)	*	*	*	**	-	*	*	7
47	Jirapinyo, P., et al. (1997)	-	-	-	**	-	*	-	3

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
48	Jitnarin, N., et al. (2008)	*	-	-	*	*	*	*	5
49	Jitramontree, N. (2003)	-	*	*	**	-	*	*	6
50	Julvanichpong Tanida (2015)	*	-	-	**	-	*	*	5
51	Junlapeeya, P. (2005)	-	*	*	**	-	*	*	6
52	Kabkaew Tatsanan (2006)	-	-	-	**	-	*	*	4
53	Kaewthummanukul et al (2008)	-	*	*	**	-	*	*	6
54	Kaewwit R. (2007)	*	*	-	**	-	*	*	6
55	Kanchanomai, S., et al. (2012)	-	-	*	**	*	*	*	6
56	Kantachuvessiri, A., et al. (2005)	*	*	*	**	*	*	*	8
57	Keawvilai Somnuk (2009)	-	*	-	**	-	*	*	5
58	Khotcharrat, R., et al. (2015)	*	*	*	*	-	**	*	7
59	Khruakhorn, S., et al. (2010)	-	*	-	*	**	*	*	6
60	Khwanchuea, R., et al (2012)	-	-	-	*	**	**	*	6
61	Kiatrungrit, K. and S. Hongsanguansri (2014)	*	-	*	*	-	*	*	5
62	Kitrungpipat N. and Phannithit A. (2012)	-	*	-	*	-	*	*	4
63	Kittipimpanon (2006)	-	*	-	**	-	**	*	6
64	Klainin-Yobas, P., et al. (2015)	-	*	-	**	-	**	*	6

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
65	Kongcheewasakul et al (2014)	*	-	-	*	-	*	-	3
66	Konharn, K., et al. (2014)	*	-	-	**	-	**	*	6
67	Konharn, K., et al. (2015)	*	-	-	**	-	**	*	6
68	Kraithaworn, P., et al. (2011)	*	*	*	**	-	*	*	7
69	Kruavit, A., et al. (2012)	-	-	-	**	-	**	*	5
70	L, L. Y. L., et al. (2009)	*	*	*	*	-	*	*	6
71	Laosupap, K., et al. (2008)	*	*	-	*	-	*	*	5
72	Lavichant A. (2006)	*	*	-	**	-	*	*	6
73	Le et al (2006)	-	-	-	*	**	**	*	6
74	Leethong-in Mayuree (2009)	*	*	*	**	-	*	*	7
75	Limpawattana, P., et al. (2016)	*	*	-	**	**	**	*	9
76	Lindholm A. and Baylis R. (2009)	-	-	*	*	-	*	*	4
77	Mahanonda, N., et al. (2000)	-	-	-	*	-	**	*	4
78	Mongkhonsiri Pitsini (2007)	-	-	-	**	-	*	*	5
79	Morinaka, T., et al. (2012)	-	-	-	**	-	**	*	5
80	Mosuwan, L. and A. F. Geater (1996)	*	-	-	*	-	**	*	5
81	Mo-suwan, L., et al. (2014)	*	*	*	*	-	*	*	6

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
82	Nakhern P. and Kananub P. (2000)	-	-	*	**	-	*	*	5
83	Nanakorn, S., et al. (1999)	-	-	-	*	-	*	*	3
84	Napradit, P., et al. (2007)	-	-	-	*	-	**	*	4
85	Narin et al (2008)	*	*	*	*	-	*	*	6
86	Ng, N., et al. (2009)	*	*	*	**	-	*	*	7
87	Ngamjaroen Annika (2005)	*	*	-	**	-	*	*	6
88	Nintachan, P. (2007)	*	*	*	**	-	*	*	7
89	Osaka, R., et al. (1999)	-	-	-	*	-	*	*	3
90	Othaganont, P., et al. (2002)	-	-	-	**	-	*	*	4
91	Page, R. M. and J. Suwanteerangkul (2009)	-	-	-	**	-	*	*	4
92	Page, R. M., et al. (2005)	-	-	-	**	**	*	*	6
93	Pancharean S. and Wanjan P. (2007)	*	*	-	**	-	*	*	6
94	Pasiri P. and Kuhirunyaratn P. (2015)	*	*	-	**	-	*	*	6
95	Pawloski, L. R., et al. (2010)	-	-	*	**	-	**	*	6
96	Peltzer, K. and S. Pengpid (2016)	*	-	-	**	-	*	*	5
97	Peltzer, K., et al. (2014)	*	-	*	**	**	*	*	8
98	Peltzer, K., et al. (2015)	-	-	*	**	-	*	*	5

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
99	Pengpid, S. and K. Peltzer (2013)	*	*	*	*	-	*	*	6
100	Pengpid, S. and K. Peltzer (2013)	*	*	*	*	-	*	*	6
101	Pengpid, S. and K. Peltzer (2015)	*	-	*	**	-	**	*	7
102	Pengpid, S., et al. (2015)	-	-	*	**	-	*	*	5
103	Pensri, P., et al (2010)	-	-	*	**	-	*	*	5
104	Piaseu, N., et al. (2001)	-	-	-	*	-	**	*	4
105	Pipatkasira, K. (2008)	*	*	-	**	-	*	*	6
106	Podang, J., et al. (2013)	-	-	-	**	**	**	*	7
107	Polin, S. (1999)	*	*	-	**	-	*	*	6
108	Pongchaiyakul, C., et al. (2004)	-	*	*	*	**	**	*	8
109	Poolsawat W. (2007)	*	*	-	**	-	*	*	6
110	Poomsrikaew Ornwanya (2011)	-	*	-	**	-	*	*	5
111	Pornsakulvanich V. (2007)	*	*	-	*	-	*	*	5
112	Pothiban, L. (1993)	*	*	*	**	-	**	*	8
113	Prapimporn Chattranukulchai, S., et al. (2015)	-	-	-	*	-	**	*	4
114	Prombumroong, J., et al. (2011)	-	-	*	**	-	*	*	5
115	Rapheeporn, K., et al. (2013)	-	-	-	*	*	**	*	5

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
116	Razzaque, A., et al. (2009)	*	-	-	**	-	**	*	6
117	Rerksuppaphol, L. and S. Rerksuppaphol (2011)	*	-	-	*	-	*	*	4
118	Ruangdaraganon, N., et al. (2002)	*	*	*	**	-	*	*	7
119	Ruangrat, Achara. (2001)	*	*	*	**	-	*	*	7
120	Rungruang et al (2006)	*	*	-	-	-	*	*	4
121	Saithong et al (2004)	*	*	-	**	-	*	*	6
122	Samnieng, P., et al. (2013)	*	-	-	*	**	**	*	7
123	Sangthong, R., et al. (2012)	*	*	*	**	**	*	*	9
124	Siangsai C. and Sukonthasab S. (2015)	*	*	-	**	-	*	*	6
125	Siramaneerat I. and Sawangdee Y. (2015)	*	*	*	*	**	*	*	8
126	Sirikulchayanonta, C., et al. (2011)	*	*	-	**	**	*	*	8
127	Siriphakhamongkhon et al (2016)	*	*	*	*	-	**	*	7
128	Siripul, P. (2000)	*	*	*	**	**	**	*	10
129	Srichaisawat, P. (2006)	-	*	-	*	-	*	*	4
130	Sritara, C., et al. (2015)	-	-	-	**	-	**	*	5
131	Stewart, O. et al. (2014)	-	*	-	**	**	*	*	7
132	Sukrasorn, S. (2008)	*	*	-	**	-	*	*	6

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
133	Sumkaew, J. (2002)	-	*	*	**	-	*	*	6
134	Sumpowthong Kaysorn (2002)	*	-	-	*	-	*	*	4
135	Sutthajunya, C. (2003)	-	*	-	**	-	*	*	5
136	Suwanachaiy Sitamanats (2007)	-	*	-	**	-	**	*	6
137	Teparatana, C. (1997)	*	*	-	**	-	*	*	6
138	Thanakwang, K. (2009)	*	*	*	*	-	*	*	6
139	Thasanasuwan, W., et al. (2016)	*	*	-	**	**	**	*	9
140	Thavillarp P. (2004)	*	*	-	**	-	*	*	6
141	Thongbai, W., et al. (2011)	*	*	-	**	*	*	*	7
142	Triprakong et al (2012)	*	*	-	**	-	*	*	6
143	Usman Y. (2004)	-	*	-	**	-	**	*	6
144	Vannarit Taweeluk (1999)	*	*	-	**	-	*	*	6
145	Vathesatogkit, P., et al. (2012)	*	-	-	**	**	**	*	8
146	Voraroon et al (2011)	-	*	*	**	-	*	*	6
147	Wakabayashi, M., et al. (2015)	*	*	*	*	**	*	*	8
148	Wannasuntad, S. (2007)	*	*	*	**	-	**	*	8
149	Watcharathanakij et al (2012)	*	*	*	**	-	*	*	7

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
150	Wattanapisit et al (2015)	-	*	*	**	-	*	*	6
151	Wattanapisit et al (2016)	-	-	*	**	-	*	*	5
152	Wattanasirichaigoon, S., et al. (2004)	*	-	*	-	-	*	*	4
153	Wattanasit Pissamai (2009)	*	*	*	**	-	*	*	7
154	Wichaidit, W., et al (2014)	*	*	*	**	**	**	*	10
155	Yamchanchai, W. (1995)	-	-	-	**	-	*	*	4
156	Yiammit Chanchalak (2013)	*	-	-	**	-	*	*	5
157	Youngpradith, A., et al. (2005)	*	-	-	**	-	*	*	5
158	เงินทอง ว. (Yuenthong et al) (2014)	-	-	-	*	-	*	*	3
159	เชยชม ก. (Cheychom Kongkiat) (2015)	*	*	-	**	-	*	*	6
160	ชลานุภาพ บ. (Chalanuphab Busarin) (2009)	-	*	-	**	-	*	*	5
161	ทองสุขนอก จ. (Thongsuknok et al) (2008)	-	*	-	**	-	*	*	5
162	นาคะ ข. N(Naka et al) (2002)	*	*	-	**	-	*	*	6
163	บุญรอง ผ. (Bunrong Pakamat) (2007)	*	*	-	**	-	*	*	6
164	พลนิล ศ. (Polnil Siwa) (2010)	-	*	-	*	-	*	*	4
165	พลรัตน์ น. (Polarat et al) (2004)	-	-	-	*	-	*	*	3

No.	Item	Sample representativeness	Sample size	Non-respondents	Ascertainment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (max=10)
166	มากเจริญ ก. (Makcharoen Korarat) (2015)	*	-	-	**	-	*	*	5
167	สุรกิจ จ, ธีรเวชเจริญชัย ส. (Surakij J. and Theerawejcharoenchai S.) (2007)	-	-	-	**	-	*	*	4

Appendix IV: Delphi

Appendix IV The Delphi Survey Questions

<u>Introductory Question</u> (to every group asking every survey round)

This survey is conducted as a part of the first round of the Delphi decisional process on classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activities by metabolic equivalents (METs), wakefulness status, and posture. You have been invited to participate as a panel member in the decisional process. Your participation in the survey is voluntary and your responses will be anonymous to the survey moderator and to other panel members. You are not required to respond to all questions, and you may quit with the survey at any time. However, to facilitate the decisional process, we would prefer if you would respond to all survey questions. Please also save your responses to open-ended questions in a Word file; just as a backup in case they are not recorded properly in the online survey.

Do you consent to participate in this survey?

- Yes
- No

<u>Questions for Group 1</u>

Q1 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet '01 employment'?

- Yes *(please go to Question 3)*
- No

Q2 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet '01 employment', what would you suggest to change and why?

Q3 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet '01 employment'?

- Yes *(please go to Question 5)*
- No

Q4 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’01 employment’, what would you suggest to change and why?

Q5 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’02 household primary work’?

- Yes *(please go to Question 7)*
- No

Q6 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’02 household primary work’, what would you suggest to change and why?

Q7 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’02 household primary work’?

- Yes *(please go to Question 9)*
- No

Q8 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’02 household primary work’, what would you suggest to change and why?

Q9 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’03 hobbies’?

- Yes *(please go to Question 11)*
- No

Q10 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’03 hobbies’, what would you suggest to change and why?

Q11 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’03 hobbies’?

- Yes *(please go to Question 13)*
- No

Q12 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’03 hobbies’, what would you suggest to change and why?

Q13 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’04 personal care’?

- Yes *(please go to Question 15)*
- No

Q14 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’04 personal care’, what would you suggest to change and why?

Q15 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’04 personal care’?

- Yes *(please skip Question 16)*
- No

Q16 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’04 personal care’, what would you suggest to change and why?

Questions for Group 2

Q1 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’01 household non primary work’?

- Yes *(please go to Question 3)*
- No

Q2 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’01 household non primary work’, what would you suggest to change and why?

Q3 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’01 household non primary work’?

- Yes *(please go to Question 5)*
- No

Q4 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’01 household non primary work’, what would you suggest to change and why?

Q5 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’02 household service’?

- Yes *(please go to Question 7)*
- No

Q6 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’02 household service’, what would you suggest to change and why?

Q7 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’02 household service’?

- Yes *(please go to Question 9)*
- No

Q8 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’02 household service’, what would you suggest to change and why?

Q9 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’03 media’?

- Yes *(please go to Question 11)*
- No

Q10 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’03 media’, what would you suggest to change and why?

Q11 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’03 media’?

- Yes *(please skip Question 12)*
- No

Q12 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’03 media’, what would you suggest to change and why?

Questions for Group 3

Q1 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’01 household construction’?

- Yes *(please go to Question 3)*
- No

Q2 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’01 household construction’, what would you suggest to change and why?

Q3 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’01 household construction’?

- Yes *(please go to Question 5)*
- No

Q4 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’01 household construction’, what would you suggest to change and why?

Q5 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’02 unpaid caregiving’?

- Yes *(please go to Question 7)*
- No

Q6 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’02 unpaid caregiving’, what would you suggest to change and why?

Q7 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’02 unpaid caregiving’?

- Yes *(please go to Question 9)*
- No

Q8 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’02 unpaid caregiving’, what would you suggest to change and why?

Q9 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’03 learning’?

- Yes *(please go to Question 11)*
- No

Q10 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’03 learning’, what would you suggest to change and why?

Q11 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’03 learning’?

- Yes *(please go to Question 13)*
- No

Q12 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’03 learning’, what would you suggest to change and why?

Q13 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’04 socializing’?

- Yes *(please go to Question 15)*
- No

Q14 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’04 socializing’, what would you suggest to change and why?

Q15 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’04 socializing’?

- Yes *(please go to Question 17)*
- No

Q16 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’04 socializing’, what would you suggest to change and why?

Q17 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’05 sport participation’?

- Yes *(please go to Question 19)*
- No

Q18 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’05 sport participation’, what would you suggest to change and why?

Q19 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’05 sport participation’?

- Yes *(please skip Question 20)*
- No

Q20 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’05 sport participation’, what would you suggest to change and why?

Questions for Group 4

Q1 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’01 unpaid domestic service’?

- Yes *(please go to Question 3)*
- No

Q2 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’01 unpaid domestic service’, what would you suggest to change and why?

Q3 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’01 unpaid domestic service’?

- Yes *(please go to Question 5)*
- No

Q4 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet ’01 unpaid domestic service’, what would you suggest to change and why?

Q5 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet ’02 community service’?

- Yes *(please go to Question 7)*
- No

Q6 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet ’02 community service’, what would you suggest to change and why?

Q7 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet ’02 community service’?

- Yes *(please go to Question 9)*
- No

Q8 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet '02 community service', what would you suggest to change and why?

Q9 Do you agree with the harmonization of ICATUS 2016 activities with corresponding ICATUS 2005 activities in the Excel spreadsheet '03 attending events'?

- Yes *(please go to Question 11)*
- No

Q10 If you disagree with the harmonization of some ICATUS 2016 and ICATUS 2005 activities in the Excel spreadsheet '03 attending events', what would you suggest to change and why?

Q11 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet '03 attending events'?

- Yes *(please skip Question 12)*
- No

Q12 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet '03 attending events', what would you suggest to change and why?

Questions for Group 5

Q1 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the ICATUS 2016 activities in the Excel spreadsheet '01 combined ICATUS 2005 activities'?

- Yes *(please go to Question 3)*
- No

Q2 If you disagree with some of the assigned codes for the ICATUS 2016 activities in the Excel spreadsheet ''01 combined ICATUS 2005 activities'', what would you suggest to change and why?

Q3 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the ICATUS 2016 activities in the Excel spreadsheet '02 combined 2016 activities'?

- Yes *(please go to Question 5)*
- No

Q4 If you disagree with some of the assigned codes for the ICATUS 2016 activities in the Excel spreadsheet '02 combined ICATUS 2016 activities', what would you suggest to change and why?

Q5 Do you agree with the assigned codes (i.e. MET values, wakefulness status, and posture) for the activities in the Excel spreadsheet '03 ICATUS 2016 activities'?

- Yes *(please skip Question 6)*
- No

Q6 If you disagree with some of the assigned codes for the activities in the Excel spreadsheet '03 ICATUS 2016', what would you suggest to change and why?

Appendix V: ISCO-88

Appendix V The list of ISCO-88 occupations classified into movement-related behaviours

ISCO-88 Code				Title	Category
1				**Legislators, senior officials and managers**	
	11			Legislators and senior officials	
		111	1110	Legislators	LPA
		112	1120	Senior government officials	LPA
		113	1130	Traditional chiefs and heads of villages	LPA
		114		Senior officials of special-interest organisations	
			1141	Senior officials of political-party organisations	LPA
			1142	Senior officials of employers', workers' and other economic-interest organisations	LPA
			1143	Senior officials of humanitarian and other special-interest organisations	LPA
	12			Corporate managers	
		121	1210	Directors and chief executives	LPA
		122		Production and operations department managers	
			1221	Production and operations department managers in agriculture, hunting, forestry and fishing	LPA
			1222	Production and operations department managers in manufacturing	LPA
			1223	Production and operations department managers in construction	LPA
			1224	Production and operations department managers in wholesale and retail trade	LPA
			1225	Production and operations department managers in restaurants and hotels	LPA
			1226	Production and operations department managers in transport, storage and communications	LPA
			1227	Production and operations department managers in business services	LPA
			1228	Production and operations department managers in personal care, cleaning and related services	LPA
			1229	Production and operations department managers not elsewhere classified	LPA
		123		Other department managers	
			1231	Finance and administration department managers	LPA
			1232	Personnel and industrial relations department managers	LPA
			1233	Sales and marketing department managers	LPA
			1234	Advertising and public relations department managers	SB
			1235	Supply and distribution department managers	SB
			1236	Computing services department managers	LPA
			1237	Research and development department managers	LPA
			1239	Other department managers not elsewhere classified	LPA
	13			General managers	
		131		General managers	
			1311	General managers in agriculture, hunting, forestry and fishing	MVPA
			1312	General managers in manufacturing	LPA
			1313	General managers in construction	LPA
			1314	General managers in wholesale and retail trade	LPA
			1315	General managers of restaurants and hotels	LPA
			1316	General managers in transport, storage and communications	LPA
			1317	General managers of business services	LPA
			1318	General managers in personal care, cleaning and related services	LPA

ISCO-88					Category
Code				Title	
			1319	General managers not elsewhere classified	LPA
2				**Professionals**	
	21			Physical, mathematical and engineering science professionals	
		211		Physicists, chemists and related professionals	
			2111	Physicists and astronomers	LPA
			2112	Meteorologists	SB
			2113	Chemists	LPA
			2114	Geologists and geophysicists	LPA
		212		Mathematicians, statisticians and related professionals	
			2121	Mathematicians and related professionals	SB
			2122	Statisticians	SB
		213		Computing professionals	
			2131	Computer systems designers and analysts	LPA
			2132	Computer programmers	SB
			2139	Computing professionals not elsewhere classified	SB
		214		Architects, engineers and related professionals	
			2141	Architects, town and traffic planners	LPA
			2142	Civil engineers	LPA
			2143	Electrical engineers	LPA
			2144	Electronics and telecommunications engineers	LPA
			2145	Mechanical engineers	LPA
			2146	Chemical engineers	LPA
			2147	Mining engineers, metallurgists and related professionals	LPA
			2148	Cartographers and surveyors	LPA
			2149	Architects, engineers and related professionals not elsewhere classified	LPA
	22			Life science and health professionals	
		221		Life science professionals	
			2211	Biologists, botanists, zoologists and related professionals	LPA
			2212	Pharmacologists, pathologists and related professionals	LPA
			2213	Agronomists and related professionals	LPA
		222		Health professionals (except nursing)	
			2221	Medical doctors	LPA
			2222	Dentists	LPA
			2223	Veterinarians	LPA
			2224	Pharmacists	LPA
			2229	Health professionals (except nursing) not elsewhere classified	LPA
		223	2230	Nursing and midwifery professionals	LPA
	23			Teaching professionals	
		231	2310	College, university and higher education teaching professionals	LPA
		232	2320	Secondary education teaching professionals	LPA
		233		Primary and pre-primary education teaching professionals	
			2331	Primary education teaching professionals	LPA
			2332	Pre-primary education teaching professionals	LPA
		234	2340	Special education teaching professionals	LPA
		235		Other teaching professionals	
			2351	Education methods specialists	LPA
			2352	School inspectors	LPA
			2359	Other teaching professionals not elsewhere classified	LPA
	24			Other professionals	
		241		Business professionals	

ISCO-88					Category
Code				Title	
			2411	Accountants	SB
			2412	Personnel and careers professionals	LPA
			2419	Business professionals not elsewhere classified	SB
		242		Legal professionals	
			2421	Lawyers	LPA
			2422	Judges	LPA
			2429	Legal professionals not elsewhere classified	LPA
		243		Archivists, librarians and related information professionals	
			2431	Archivists and curators	SB
			2432	Librarians and related information professionals	LPA
		244		Social science and related professionals	
			2441	Economists	SB
			2442	Sociologists, anthropologists and related professionals	SB
			2443	Philosophers, historians and political scientists	LPA
			2444	Philologists, translators and interpreters	SB
			2445	Psychologists	SB
			2446	Social work professionals	LPA
		245		Writers and creative or performing artists	
			2451	Authors, journalists and other writers	SB
			2452	Sculptors, painters and related artists	LPA
			2453	Composers, musicians and singers	LPA
			2454	Choreographers and dancers	MVPA
			2455	Film, stage and related actors and directors	LPA
		246	2460	Religious professionals	LPA
3				**Technicians and associate professionals**	
	31			Physical and engineering science associate professionals	
		311		Physical and engineering science technicians	
			3111	Chemical and physical science technicians	LPA
			3112	Civil engineering technicians	LPA
			3113	Electrical engineering technicians	LPA
			3114	Electronics and telecommunications engineering technicians	LPA
			3115	Mechanical engineering technicians	LPA
			3116	Chemical engineering technicians	LPA
			3117	Mining and metallurgical technicians	LPA
			3118	Draughtspersons	SB
			3119	Physical and engineering science technicians not elsewhere classified	LPA
		312		Computer associate professionals	
			3121	Computer assistants	LPA
			3122	Computer equipment operators	LPA
			3123	Industrial robot controllers	LPA
		313		Optical and electronic equipment operators	
			3131	Photographers and image and sound recording equipment operators	LPA
			3132	Broadcasting and telecommunications equipment operators	LPA
			3133	Medical equipment operators	LPA
			3139	Optical and electronic equipment operators not elsewhere classified	LPA
		314		Ship and aircraft controllers and technicians	
			3141	Ships' engineers	LPA
			3142	Ships' deck officers and pilots	LPA
			3143	Aircraft pilots and related associate professionals	LPA
			3144	Air traffic controllers	LPA

ISCO-88					Category
Code				Title	
			3145	Air traffic safety technicians	LPA
		315		Safety and quality inspectors	
			3151	Building and fire inspectors	LPA
			3152	Safety, health and quality inspectors	LPA
	32			Life science and health associate professionals	
		321		Life science technicians and related associate professionals	
			3211	Life science technicians	LPA
			3212	Agronomy and forestry technicians	LPA
			3213	Farming and forestry advisers	LPA
		322		Modern health associate professionals (except nursing)	
			3221	Medical assistants	LPA
			3222	Sanitarians	LPA
			3223	Dieticians and nutritionists	LPA
			3224	Optometrists and opticians	LPA
			3225	Dental assistants	LPA
			3226	Physiotherapists and related associate professionals	LPA
			3227	Veterinary assistants	LPA
			3228	Pharmaceutical assistants	LPA
			3229	Modern health associate professionals (except nursing) not elsewhere classified	LPA
		323		Nursing and midwifery associate professionals	
			3231	Nursing associate professionals	LPA
			3232	Midwifery associate professionals	LPA
		324		Traditional medicine practitioners and faith healers	
			3241	Traditional medicine practitioners	LPA
			3242	Faith healers	LPA
	33			Teaching associate professionals	
		331	3310	Primary education teaching associate professionals	LPA
		332	3320	Pre-primary education teaching associate professionals	LPA
		333	3330	Special education teaching associate professionals	LPA
		334	3340	Other teaching associate professionals	LPA
	34			Other associate professionals	
		341		Finance and sales associate professionals	
			3411	Securities and finance dealers and brokers	SB
			3412	Insurance representatives	SB
			3413	Estate agents	LPA
			3414	Travel consultants and organisers	SB
			3415	Technical and commercial sales representatives	SB
			3416	Buyers	SB
			3417	Appraisers, valuers and auctioneers	SB
			3419	Finance and sales associate professionals not elsewhere classified	SB
		342		Business services agents and trade brokers	
			3421	Trade brokers	SB
			3422	Clearing and forwarding agents	LPA
			3423	Employment agents and labour contractors	SB
			3429	Business services agents and trade brokers not elsewhere classified	LPA
		343		Administrative associate professionals	
			3431	Administrative secretaries and related associate professionals	LPA
			3432	Legal and related business associate professionals	LPA
			3433	Bookkeepers	SB

ISCO-88					Category
Code				Title	
			3434	Statistical, mathematical and related associate professionals	SB
			3439	Administrative associate professionals not elsewhere classified	LPA
		344		Customs, tax and related government associate professionals	
			3441	Customs and border inspectors	LPA
			3442	Government tax and excise officials	SB
			3443	Government social benefits officials	SB
			3444	Government licensing officials	SB
			3449	Customs, tax and related government associate professionals not elsewhere classified	LPA
		345	3450	Police inspectors and detectives	LPA
		346	3460	Social work associate professionals	LPA
		347		Artistic, entertainment and sports associate professionals	
			3471	Decorators and commercial designers	LPA
			3472	Radio, television and other announcers	LPA
			3473	Street, night-club and related musicians, singers and dancers	LPA
			3474	Clowns, magicians, acrobats and related associate professionals	LPA
			3475	Athletes, sportspersons and related associate professionals	MVPA
		348	3480	Religious associate professionals	LPA
4				**Clerks**	
	41			Office clerks	
		411		Secretaries and keyboard-operating clerks	
			4111	Stenographers and typists	LPA
			4112	Word-processor and related operators	LPA
			4113	Data entry operators	SB
			4114	Calculating-machine operators	LPA
			4115	Secretaries	LPA
		412		Numerical clerks	
			4121	Accounting and bookkeeping clerks	LPA
			4122	Statistical and finance clerks	LPA
		413		Material-recording and transport clerks	
			4131	Stock clerks	LPA
			4132	Production clerks	LPA
			4133	Transport clerks	LPA
		414		Library, mail and related clerks	
			4141	Library and filing clerks	LPA
			4142	Mail carriers and sorting clerks	LPA
			4143	Coding, proof-reading and related clerks	LPA
			4144	Scribes and related workers	LPA
		419	4190	Other office clerks	SB
	42			Customer services clerks	
		421		Cashiers, tellers and related clerks	
			4211	Cashiers and ticket clerks	LPA
			4212	Tellers and other counter clerks	SB
			4213	Bookmakers and croupiers	LPA
			4214	Pawnbrokers and money-lenders	LPA
			4215	Debt-collectors and related workers	LPA
		422		Client information clerks	
			4221	Travel agency and related clerks	SB
			4222	Receptionists and information clerks	LPA
			4223	Telephone switchboard operators	LPA

ISCO-88					Category
Code				Title	
5				**Service workers and shop and market sales workers**	
	51			Personal and protective services workers	
		511		Travel attendants and travel stewards	
			5111	Travel attendants and travel stewards	LPA
			5112	Transport conductors	LPA
			5113	Travel guides	LPA
		512		Housekeeping and restaurant services workers	
			5121	Housekeepers and related workers	LPA
			5122	Cooks	LPA
			5123	Waiters, waitresses and bartenders	LPA
		513		Personal care and related workers	
			5131	Child-care workers	LPA
			5132	Institution-based personal care workers	LPA
			5133	Home-based personal care workers	LPA
			5139	Personal care and related workers not elsewhere classified	LPA
		514		Other personal services workers	
			5141	Hairdressers, barbers, beauticians and related workers	LPA
			5142	Companions and valets	LPA
			5143	Undertakers and embalmers	LPA
			5149	Other personal services workers not elsewhere classified	LPA
		515		Astrologers, fortune-tellers and related workers	
			5151	Astrologers and related workers	SB
			5152	Fortune-tellers, palmists and related workers	SB
		516		Protective services workers	
			5161	Fire-fighters	MVPA
			5162	Police officers	MVPA
			5163	Prison guards	LPA
			5169	Protective services workers not elsewhere classified	LPA
	52			Models, salespersons and demonstrators	
		521	5210	Fashion and other models	LPA
		522	5220	Shop salespersons and demonstrators	LPA
		523	5230	Stall and market salespersons	LPA
6				**Skilled agricultural and fishery workers**	
	61			Market-oriented skilled agricultural and fishery workers	
		611		Market gardeners and crop growers	
			6111	Field crop and vegetable growers	MVPA
			6112	Tree and shrub crop growers	MVPA
			6113	Gardeners, horticultural and nursery growers	MVPA
			6114	Mixed-crop growers	LPA
		612		Market-oriented animal producers and related workers	
			6121	Dairy and livestock producers	MVPA
			6122	Poultry producers	LPA
			6123	Apiarists and sericulturists	LPA
			6124	Mixed-animal producers	LPA
			6129	Market-oriented animal producers and related workers not elsewhere classified	LPA
		613	6130	Market-oriented crop and animal producers	MVPA
		614		Forestry and related workers	
			6141	Forestry workers and loggers	MVPA
			6142	Charcoal burners and related workers	MVPA

ISCO-88					Category
Code				Title	
		615		Fishery workers, hunters and trappers	
			6151	Aquatic-life cultivation workers	LPA
			6152	Inland and coastal waters fishery workers	MVPA
			6153	Deep-sea fishery workers	MVPA
			6154	Hunters and trappers	LPA
	62			Subsistence agricultural and fishery workers	
		621	6210	Subsistence agricultural and fishery workers	MVPA
7				**Craft and related trades workers**	
	71			Extraction and building trades workers	
		711		Miners, shotfirers, stone cutters and carvers	
			7111	Miners and quarry workers	LPA
			7112	Shotfirers and blasters	LPA
			7113	Stone splitters, cutters and carvers	MVPA
		712		Building frame and related trades workers	
			7121	Builders, traditional materials	MVPA
			7122	Bricklayers and stonemasons	MVPA
			7123	Concrete placers, concrete finishers and related workers	MVPA
			7124	Carpenters and joiners	MVPA
			7129	Building frame and related trades workers not elsewhere classified	MVPA
		713		Building finishers and related trades workers	
			7131	Roofers	MVPA
			7132	Floor layers and tile setters	MVPA
			7133	Plasterers	MVPA
			7134	Insulation workers	LPA
			7135	Glaziers	MVPA
			7136	Plumbers and pipe fitters	MVPA
			7137	Building and related electricians	LPA
		714		Painters, building structure cleaners and related trades workers	
			7141	Painters and related workers	LPA
			7142	Varnishers and related painters	MVPA
			7143	Building structure cleaners	MVPA
	72			Metal, machinery and related trades workers	
		721		Metal moulders, welders, sheet-metal workers, structural-metal preparers, and related trades workers	
			7211	Metal moulders and coremakers	LPA
			7212	Welders and flamecutters	LPA
			7213	Sheet-metal workers	LPA
			7214	Structural-metal preparers and erectors	MVPA
			7215	Riggers and cable splicers	MVPA
			7216	Underwater workers	MVPA
		722		Blacksmiths, tool-makers and related trades workers	
			7221	Blacksmiths, hammer-smiths and forging-press workers	MVPA
			7222	Tool-makers and related workers	LPA
			7223	Machine-tool setters and setter-operators	LPA
			7224	Metal wheel-grinders, polishers and tool sharpeners	LPA
		723		Machinery mechanics and fitters	
			7231	Motor vehicle mechanics and fitters	LPA
			7232	Aircraft engine mechanics and fitters	LPA
			7233	Agricultural- or industrial-machinery mechanics and fitters	LPA
		724		Electrical and electronic equipment mechanics and fitters	

ISCO-88					Category
Code				Title	
			7241	Electrical mechanics and fitters	MVPA
			7242	Electronics fitters	LPA
			7243	Electronics mechanics and servicers	LPA
			7244	Telegraph and telephone installers and servicers	LPA
			7245	Electrical line installers, repairers and cable jointers	LPA
	73			Precision, handicraft, printing and related trades workers	
		731		Precision workers in metal and related materials	
			7311	Precision-instrument makers and repairers	LPA
			7312	Musical instrument makers and tuners	LPA
			7313	Jewellery and precious-metal workers	LPA
		732		Potters, glass-makers and related trades workers	
			7321	Abrasive wheel formers, potters and related workers	LPA
			7322	Glass-makers, cutters, grinders and finishers	LPA
			7323	Glass engravers and etchers	LPA
			7324	Glass, ceramics and related decorative painters	LPA
		733		Handicraft workers in wood, textile, leather and related materials	
			7331	Handicraft workers in wood and related materials	LPA
			7332	Handicraft workers in textile, leather and related materials	LPA
		734		Printing and related trades workers	
			7341	Compositors, typesetters and related workers	LPA
			7342	Stereotypers and electrotypers	LPA
			7343	Printing engravers and etchers	LPA
			7344	Photographic and related workers	LPA
			7345	Bookbinders and related workers	LPA
			7346	Silk-screen, block and textile printers	LPA
	74			Other craft and related trades workers	
		741		Food processing and related trades workers	
			7411	Butchers, fishmongers and related food preparers	LPA
			7412	Bakers, pastry-cooks and confectionery makers	LPA
			7413	Dairy-products makers	LPA
			7414	Fruit, vegetable and related preservers	LPA
			7415	Food and beverage tasters and graders	LPA
			7416	Tobacco preparers and tobacco products makers	LPA
		742		Wood treaters, cabinet-makers and related trades workers	
			7421	Wood treaters	LPA
			7422	Cabinet-makers and related workers	LPA
			7423	Woodworking-machine setters and setter-operators	LPA
			7424	Basketry weavers, brush makers and related workers	LPA
		743		Textile, garment and related trades workers	
			7431	Fibre preparers	LPA
			7432	Weavers, knitters and related workers	LPA
			7433	Tailors, dressmakers and hatters	LPA
			7434	Furriers and related workers	LPA
			7435	Textile, leather and related pattern-makers and cutters	LPA
			7436	Sewers, embroiderers and related workers	LPA
			7437	Upholsterers and related workers	LPA
		744		Pelt, leather and shoemaking trades workers	
			7441	Pelt dressers, tanners and fellmongers	MVPA
			7442	Shoe-makers and related workers	LPA
8				**Plant and machine operators and assemblers**	

ISCO-88					Category
Code				Title	
	81			Stationary-plant and related operators	
		811		Mining- and mineral-processing-plant operators	
			8111	Mining-plant operators	LPA
			8112	Mineral-ore- and stone-processing-plant operators	LPA
			8113	Well drillers and borers and related workers	MVPA
		812		Metal-processing-plant operators	
			8121	Ore and metal furnace operators	LPA
			8122	Metal melters, casters and rolling-mill operators	LPA
			8123	Metal-heat-treating-plant operators	LPA
			8124	Metal drawers and extruders	LPA
		813		Glass, ceramics and related plant operators	
			8131	Glass and ceramics kiln and related machine operators	LPA
			8139	Glass, ceramics and related plant operators not elsewhere classified	LPA
		814		Wood-processing- and papermaking-plant operators	
			8141	Wood-processing-plant operators	MVPA
			8142	Paper-pulp plant operators	LPA
			8143	Papermaking-plant operators	LPA
		815		Chemical-processing-plant operators	
			8151	Crushing-, grinding- and chemical-mixing machinery operators	LPA
			8152	Chemical-heat-treating-plant operators	LPA
			8153	Chemical-filtering- and separating-equipment operators	LPA
			8154	Chemical-still and reactor operators (except petroleum and natural gas)	LPA
			8155	Petroleum- and natural-gas-refining-plant operators	LPA
			8159	Chemical-processing-plant operators not elsewhere classified	LPA
		816		Power-production and related plant operators	
			8161	Power-production plant operators	LPA
			8162	Steam-engine and boiler operators	LPA
			8163	Incinerator, water-treatment and related plant operators	LPA
		817		Automated-assembly-line and industrial-robot operators	
			8171	Automated-assembly-line operators	LPA
			8172	Industrial-robot operators	LPA
	82			Machine operators and assemblers	
		821		Metal- and mineral-products machine operators	
			8211	Machine-tool operators	LPA
			8212	Cement and other mineral products machine operators	LPA
		822		Chemical-products machine operators	
			8221	Pharmaceutical- and toiletry-products machine operators	LPA
			8222	Ammunition- and explosive-products machine operators	LPA
			8223	Metal finishing-, plating- and coating-machine operators	LPA
			8224	Photographic-products machine operators	LPA
			8229	Chemical-products machine operators not elsewhere classified	LPA
		823		Rubber- and plastic-products machine operators	
			8231	Rubber-products machine operators	LPA
			8232	Plastic-products machine operators	LPA
		824	8240	Wood-products machine operators	LPA
		825		Printing-, binding- and paper-products machine operators	
			8251	Printing-machine operators	LPA
			8252	Bookbinding-machine operators	LPA
			8253	Paper-products machine operators	LPA
		826		Textile-, fur- and leather-products machine operators	

ISCO-88					Category
Code				Title	
			8261	Fibre-preparing-, spinning- and winding-machine operators	LPA
			8262	Weaving- and knitting-machine operators	LPA
			8263	Sewing-machine operators	LPA
			8264	Bleaching-, dyeing- and cleaning-machine operators	LPA
			8265	Fur- and leather-preparing-machine operators	LPA
			8266	Shoemaking- and related machine operators	LPA
			8269	Textile-, fur- and leather-products machine operators not elsewhere classified	LPA
		827		Food and related products machine operators	
			8271	Meat- and fish-processing-machine operators	LPA
			8272	Dairy-products machine operators	LPA
			8273	Grain- and spice-milling-machine operators	LPA
			8274	Baked-goods, cereal and chocolate-products machine operators	LPA
			8275	Fruit-, vegetable- and nut-processing-machine operators	LPA
			8276	Sugar production machine operators	LPA
			8277	Tea-, coffee-, and cocoa-processing-machine operators	LPA
			8278	Brewers-, wine and other beverage machine operators	LPA
			8279	Tobacco production machine operators	LPA
		828		Assemblers	
			8281	Mechanical-machinery assemblers	LPA
			8282	Electrical-equipment assemblers	LPA
			8283	Electronic-equipment assemblers	LPA
			8284	Metal-, rubber- and plastic-products assemblers	LPA
			8285	Wood and related products assemblers	LPA
			8286	Paperboard, textile and related products assemblers	LPA
		829	8290	Other machine operators and assemblers	LPA
	83			Drivers and mobile-plant operators	
		831		Locomotive-engine drivers and related workers	
			8311	Locomotive-engine drivers	LPA
			8312	Railway brakers, signallers and shunters	LPA
		832		Motor-vehicle drivers	
			8321	Motor-cycle drivers	MVPA
			8322	Car, taxi and van drivers	LPA
			8323	Bus and tram drivers	LPA
			8324	Heavy truck and lorry drivers	LPA
		833		Agricultural and other mobile-plant operators	
			8331	Motorised farm and forestry plant operators	LPA
			8332	Earth-moving- and related plant operators	LPA
			8333	Crane, hoist and related plant operators	LPA
			8334	Lifting-truck operators	LPA
		834	8340	Ships' deck crews and related workers	LPA
9				**Elementary occupations**	
	91			Sales and services elementary occupations	
		911		Street vendors and related workers	
			9111	Street food vendors	LPA
			9112	Street vendors, non-food products	LPA
			9113	Door-to-door and telephone salespersons	LPA
		912	9120	Shoe cleaning and other street services elementary occupations	LPA
		913		Domestic and related helpers, cleaners and launderers	
			9131	Domestic helpers and cleaners	LPA

ISCO-88					Category
Code				Title	
			9132	Helpers and cleaners in offices, hotels and other establishments	LPA
			9133	Hand-launderers and pressers	LPA
		914		Building caretakers, window and related cleaners	
			9141	Building caretakers	LPA
			9142	Vehicle, window and related cleaners	MVPA
		915		Messengers, porters, doorkeepers and related workers	
			9151	Messengers, package and luggage porters and deliverers	LPA
			9152	Doorkeepers, watchpersons and related workers	LPA
			9153	Vending-machine money collectors, meter readers and related workers	LPA
		916		Garbage collectors and related labourers	
			9161	Garbage collectors	MVPA
			9162	Sweepers and related labourers	MVPA
	92			Agricultural, fishery and related labourers	
		921		Agricultural, fishery and related labourers	
			9211	Farm-hands and labourers	MVPA
			9212	Forestry labourers	MVPA
			9213	Fishery, hunting and trapping labourers	MVPA
	93			Labourers in mining, construction, manufacturing and transport	
		931		Mining and construction labourers	
			9311	Mining and quarrying labourers	MVPA
			9312	Construction and maintenance labourers: roads, dams and similar constructions	MVPA
			9313	Building construction labourers	MVPA
		932		Manufacturing labourers	
			9321	Assembling labourers	MVPA
			9322	Hand packers and other manufacturing labourers	MVPA
		933		Transport labourers and freight handlers	
			9331	Hand or pedal vehicle drivers	MVPA
			9332	Drivers of animal-drawn vehicles and machinery	MVPA
			9333	Freight handlers	MVPA
0				**Armed forces**	
	01			Armed forces	
		011	0110	Armed forces	LPA

Appendix VI: ICATUS 2005

Appendix VI Metabolic equivalent (MET) values, summary codes and movement categories assigned to International Classification of Activities for Time Use Statistics (ICATUS) 2005 activities

ICATUS 2005 activity				Category	MET	Wakefulness	Sitting/ lying
Code			Title				
0111			**Working time in "formal sector" employment**				
	01111	011110	Working time in main job	n/a	n/a	n/a	n/a
	01112	011120	Working time in other jobs	n/a	n/a	n/a	n/a
	01113	011130	Working time as apprentice, intern and related positions	n/a	n/a	n/a	n/a
	01114	011140	Short breaks and interruptions from work	SB	1.30	yes	yes
	01115	011150	Training and studies in relation to work in the "formal sector"	LPA	1.80	yes	yes
	0111x		Working time in "formal sector" employment n.f.d.	n/a	n/a	n/a	n/a
0112			**Other breaks**				
	01121	011210	Idle time before/after work	SB	1.30	yes	yes
	01122	011220	Lunch break from work	SB	1.50	yes	yes
0120			**Looking for work/setting up business in the "formal sector"**				
	01201	012010	Looking for work in the "formal sector"	SB	1.40	yes	yes
	01202	012020	Looking for/setting up business in the "formal sector"	LPA	1.65	yes	yes
0130			**Travel related to work in the "formal sector"**				
	01300	013000	Travel related to work in the "formal sector"	n/a	n/a	n/a	n/a
0190			**Work in the "formal sector" n.e.c.**				
	01900	019000	Work in the "formal sector" n.e.c.	n/a	n/a	n/a	n/a
0211			**Working time in primary production activities**				
	02111		Growing of crops and trees; kitchen gardening	MVPA	3.55	yes	no
		021111	Land preparation	MVPA	5.40	yes	no
		021112	Sowing and planting operations	MVPA	4.30	yes	no
		021113	Collecting and preparing organic fertilizer, carrying and spreading organic/chemical fertilizer	MVPA	3.15	yes	no
		021114	Field/garden upkeep	MVPA	3.90	yes	no
		021115	Harvesting	MVPA	3.55	yes	no
		021116	Post-harvest activities	MVPA	3.50	yes	no
		021117	Other agricultural service activities	MVPA	3.50	yes	no
		021119	Other specified activities related to growing of crops and trees	MVPA	3.55	yes	no
		02111x	Growing of crops and trees; kitchen gardening n.f.d.	MVPA	3.55	yes	no
	02112		Farming of animals; production of animal products; animal husbandry services	MVPA	4.30	yes	no
		021121	Fodder collection; preparation of feed; feeding, watering; grazing	MVPA	4.30	yes	no
		021122	Grooming, shoeing, cleaning; veterinary care	MVPA	4.50	yes	no
		021123	Washing shed, coop cleaning	MVPA	4.80	yes	no
		021124	Work related to breeding; hatching	MVPA	4.65	yes	no
		021125	Milking and processing of raw milk	LPA	2.40	yes	no
		021126	Collecting, storing, grading of eggs	MVPA	3.30	yes	no
		021127	Shearing, producing hides and skins from ranching	MVPA	4.00	yes	no
		021128	Dung-gathering and making dung cakes	MVPA	4.30	yes	no
		021129	Other specified activities related to animal farming, production of animal products, animal husbandry services	MVPA	4.30	yes	no
		02112x	Farming of animals; production of animal products; animal husbandry services n.f.d.	MVPA	4.30	yes	no
	02113		Hunting, trapping and production of animal skins	MVPA	3.30	yes	no

ICATUS 2005 activity Code		Title	Category	MET	Wakefulness	Sitting/ lying
	021131	Hunting and trapping wild animals	LPA	2.50	yes	no
	021132	Hunting birds	MVPA	3.30	yes	no
	021133	Production of fur skins, reptile or bird skins from hunting and trapping	MVPA	3.50	yes	no
	021139	Other specified activities related to hunting and production of animal skins	MVPA	3.30	yes	no
	02113x	Hunting, trapping and production of animal skins n.f.d.	MVPA	3.30	yes	no
02114		Gathering of wild products, woodcutting, gathering firewood and other forestry activities	MVPA	3.90	yes	no
	021141	Gathering medicinal and other plants for craft production or fuel	MVPA	3.50	yes	no
	021142	Gathering wild fruits, berries or other uncultivated crops, other edible food	MVPA	3.50	yes	no
	021143	Woodcutting and gathering firewood	MVPA	5.30	yes	no
	021144	Reforestation, growing forest trees, replanting	MVPA	4.30	yes	no
	021149	Other specified activities related to hunting, forestry, and gathering of wild products	MVPA	3.90	yes	no
	02114x	Gathering of wild products, woodcutting, gathering firewood and other forestry activities n.f.d.	MVPA	3.90	yes	no
02115		Fishing and fish/aquatic farming	MVPA	4.15	yes	no
	021151	Catching fish and gathering other forms of aquatic life	MVPA	4.00	yes	no
	021152	Gathering marine materials such as natural pearls, sponges, corals, algae, seashells	MVPA	6.00	yes	no
	021153	Fish/aquatic farming: breeding, rearing	MVPA	4.65	yes	no
	021154	Fish/aquatic farming: cleaning beds, feeding	MVPA	4.15	yes	no
	021155	Repair, care and maintenance of fishing boats and equipment, tools, fishnets	MVPA	3.50	yes	no
	021159	Other specified activities related to fishing, fish/aquatic farming	MVPA	4.15	yes	no
	02115x	Fishing and fish/aquatic farming n.f.d.	MVPA	4.15	yes	no
02116		Mining and quarrying	MVPA	5.50	yes	no
	021161	Mining/extraction of salt	MVPA	5.50	yes	no
	021162	Drilling well, boring holes etc	MVPA	5.80	yes	no
	021163	Quarrying of stone slabs	MVPA	5.50	yes	no
	021164	Crushing and breaking of stones	MVPA	6.00	yes	no
	021165	Digging out clay, gravel and sand	MVPA	5.90	yes	no
	021166	Gold panning, mining gems etc.	MVPA	5.50	yes	no
	021167	Transporting, storing and stocking	MVPA	3.00	yes	no
	021169	Other specified mining and quarrying activities	MVPA	5.50	yes	no
	02116x	Mining and quarrying n.f.d.	MVPA	5.50	yes	no
02117	021170	Collecting water	MVPA	4.30	yes	no
02118	021180	Training and studies in relation to work in primary production activities of households	LPA	2.40	yes	yes
0211x		Working time in primary production activities n.f.d.	MVPA	4.03	yes	no
0212		**Working time in primary production activities**				
02121	021210	Purchasing/acquiring inputs/supplies used for primary production activities of households	LPA	2.05	yes	no
02122	021220	Selling/disposing of outputs of primary production activities of households	LPA	2.00	yes	no
0220		**Looking for work/setting up business in household primary production activities**				
02201	022010	Looking for work in primary production activities in household enterprise	SB	1.50	yes	yes
02202	022020	Looking for/setting up business in primary production activities in household enterprise	LPA	1.65	yes	yes
0230		**Travel related to primary production activities of households**				

ICATUS 2005 activity				Category	MET	Wakefulness	Sitting/ lying
Code			Title				
	02300	023000	Travel related to primary production activities of households	n/a	n/a	n/a	n/a
0290			**Work for households in primary production activities n.e.c.**				
	02900	029000	Work for households in primary production activities n.e.c.	MVPA	3.55	yes	no
0311			**Working time in non-primary production activities**				
	03111		Processing of food products	LPA	2.50	yes	no
		031111	Production, processing and preserving of meat and meat products	MVPA	3.00	yes	no
		031112	Making dairy products	LPA	2.00	yes	no
		031113	Processing and preserving of fish and fish products	LPA	2.30	yes	no
		031114	Processing and preserving of fruits and vegetables	LPA	2.50	yes	no
		031115	Processing grains	LPA	2.90	yes	no
		031119	Other specified activities related to processing of food products	LPA	2.50	yes	no
		03111x	Processing of food products n.f.d.	LPA	2.50	yes	no
	03112		Making of other food products and beverages	LPA	2.83	yes	no
		031121	Beer brewing and making of other beverages, wines or spirits	MVPA	3.25	yes	no
		031122	Baking bread, cakes, rice cakes, pastries, pies, tarts, biscuits	MVPA	3.00	yes	no
		031123	Making noodles, pasta and similar products	MVPA	3.00	yes	no
		031124	Making candy, boiled sweets, caramel, chocolate, and other sugar confectionery products	LPA	2.65	yes	no
		031125	Roasting seeds, nuts	LPA	2.00	yes	no
		031126	Roasting, grinding coffee beans	LPA	2.15	yes	no
		031129	Other specified activities related to making of other food products and beverages	LPA	2.83	yes	no
		03112x	Making of other food products and beverages n.f.d.	LPA	2.83	yes	no
	03113		Making textiles, wearing apparel, leather and associated products	MVPA	3.00	yes	yes
		031131	Spinning, weaving, finishing of textiles	MVPA	3.00	yes	yes
		031132	Producing articles from textile except apparel	LPA	2.00	yes	yes
		031133	Making wearing apparel	LPA	2.40	yes	yes
		031134	Curing of skins and production of leather, tanning and dressing of leather	MVPA	3.50	yes	no
		031135	Making shoes, footwear, handbags, luggage	MVPA	3.00	yes	yes
		031139	Other specified activities related to making textiles, wearing apparel, leather and associated products	MVPA	3.00	yes	yes
		03113x	Making textiles, wearing apparel, leather and associated products n.f.d.	MVPA	3.00	yes	yes
	03114		Craft-making using all types of materials	MVPA	3.00	yes	yes
		031141	Making wood products including furniture, fixtures or furnishings, statuettes and other ornaments	MVPA	3.30	yes	no
		031142	Making baskets, wickerwork and other similar products	MVPA	3.00	yes	yes
		031143	Fabricating utensils, cutlery, hand tools and other metal products	MVPA	3.00	yes	no
		031144	Metal working	MVPA	4.50	yes	no
		031145	Making pottery, ovens and cooking stoves, ornaments etc. from clay, plaster or cement	MVPA	3.00	yes	yes
		031146	Making paper and paper products; paper crafts	LPA	2.05	yes	yes
		031147	Making soap, perfume, candles etc.	MVPA	3.25	yes	no
		031149	Other specified activities related to craft-making	MVPA	3.00	yes	yes
		03114x	Craft-making using all types of materials n.f.d.	MVPA	3.00	yes	yes
	03115	031150	Tobacco preparing and curing	MVPA	3.00	yes	no
	03116	031160	Making bricks, concrete slabs, hollow blocks, tiles etc.	MVPA	4.75	yes	no
	03117	031170	Making herbal and medicinal preparations	SB	1.40	yes	yes

ICATUS 2005 activity Code			Title	Category	MET	Wakefulness	Sitting/ lying
	03118	031180	Training and studies in relation to work in non-primary production activities of households	LPA	2.40	yes	yes
	0311x		Working time in non-primary production activities n.f.d	LPA	2.91	yes	no
0312			**Acquiring inputs/supplies and disposing of outputs used for non-primary production activities households**				
	03121	031210	Purchasing/acquiring inputs/supplies used for non-primary production activities for households	LPA	2.05	yes	no
	03122	031220	Selling/disposing of outputs of non-primary production activities of households	LPA	2.00	yes	no
0320			**Looking for work/setting up business in non-primary production activities in household enterprise**				
	03201	032010	Looking for work in non-primary production activities in household enterprise	SB	1.50	yes	yes
	03202	032020	Looking for/setting up business in non-primary production activities in household enterprise	LPA	1.65	yes	yes
0330			**Travel related to non-primary production of household**				
	03300	033000	Travel related to non-primary production of household	n/a	n/a	n/a	n/a
0390			**Work for household in non-primary production activities n.e.c.**				
	03900	039000	Work for household in non-primary production activities n.e.c.	LPA	2.50	yes	no
0411			**Working time in construction activities**				
	04111		Construction and repair for own capital formation	MVPA	4.30	yes	no
		041111	Building of own house	MVPA	4.30	yes	no
		041112	Major home improvements and repairs	MVPA	4.00	yes	no
		041113	Building and repair of animal and poultry sheds/shelter, business place, field walls/fences, storage facilities for farm produce, irrigation	MVPA	4.30	yes	no
		041119	Other specified activities related to construction and repair for own capital formation	MVPA	4.30	yes	no
		04111x	Construction and repair for own capital formation n.f.d.	MVPA	4.30	yes	no
	04112	041120	Construction and repair of buildings, roads, dams and other structures	MVPA	4.50	yes	no
	04113	041130	Community-organized construction and major repairs of roads, buildings, bridges, dams etc.	MVPA	4.50	yes	no
	04114	041140	Training and studies in relation to work in construction activities in household enterprise	MVPA	3.25	yes	no
	0411x		Working time in construction activities n.f.d.	MVPA	4.40	yes	no
0412			**Acquiring inputs/supplies for construction activities for household production**				
	04120	041200	Purchasing/acquiring inputs/supplies for construction activities for household production	LPA	1.80	yes	yes
0420			**Looking for work/setting up business in construction activities in household enterprise**				
	04201	042010	Looking for work in construction activities in household enterprise	SB	1.50	yes	yes
	04202	042020	Looking for/setting up business in construction activities as household enterprise	LPA	1.65	yes	yes
0430			**Travel related to construction activities of households**				
	04300	043000	Travel related to construction activities of households	n/a	n/a	n/a	n/a
0490			**Work for household in construction activities n.e.c.**				
	04900	049000	Work for household in construction activities n.e.c.	MVPA	3.78	yes	no
0511			**Food vending and trading**				
	05111		Preparing and selling food and beverage	MVPA	3.00	yes	no
		051111	Preparing/packing food and beverage preparations	MVPA	3.00	yes	no
		051112	Selling/delivering food and beverage preparations	MVPA	3.00	yes	no
		051113	Putting up food stalls; cleaning and maintenance	LPA	2.50	yes	no
		051119	Other specified activities related to preparing and selling food and beverage	MVPA	3.00	yes	no

ICATUS 2005 activity				Category	MET	Wakeful ness	Sitting/ lying
Code			Title				
		05111x	Preparing and selling food and beverage n.f.d.	MVPA	3.00	yes	no
	05112		Petty trading, door-to-door vending, street vending, hawking	LPA	2.00	yes	no
		051121	Petty trading	LPA	2.00	yes	no
		051122	Door-to-door vending	MVPA	3.50	yes	no
		051123	Street vending, hawking and other itinerant trading	LPA	1.90	yes	no
		051129	Other specified activities related to petty trading and vending activities	LPA	2.00	yes	no
		05112x	Trading n.f.d.	LPA	2.00	yes	no
0512			**Providing repair, installation and maintenance services**				
	05121	051210	Fitting, installing, tool setting, maintaining and repairing tools and machinery	MVPA	3.00	yes	no
	05122	051220	Repair of vehicles	MVPA	3.65	yes	no
	05123	051230	Repair of personal goods	LPA	2.30	yes	no
	05124	051240	Repair of household goods	MVPA	3.00	yes	no
0513			**Providing business and professional services**				
	05131	051310	Renting out rooms, sleeping space and associated work	LPA	1.65	yes	yes
	05132	051320	Lending and collecting money; foreign exchange	SB	1.50	yes	yes
	05133	051330	Typing, word-processing, programming, encoding	SB	1.30	yes	yes
	05134	051340	Accounting, bookkeeping, legal and related services	SB	1.30	yes	yes
	05135	051350	Tutoring	LPA	1.65	yes	yes
	05136	051360	Provision of medical and dental services	LPA	2.00	yes	no
	05137	051370	Provision of nursing/therapy services	LPA	2.00	yes	no
0514			**Providing personal care services**				
	05141	051410	Provision of personal care services	LPA	1.80	yes	no
	05142	051420	Provision of non-professional health-care	LPA	2.00	yes	no
0515			**Transporting goods and passengers**				
	05151	051510	Transporting goods	LPA	2.50	yes	yes
	05152	051520	Transporting passengers	LPA	2.50	yes	yes
0516			**Paid domestic services**				
	05160	051600	Providing paid domestic services	LPA	2.23	yes	no
0517			**Meetings/training and studies**				
	05170	051700	Training and studies related to work in service activities	LPA	1.65	yes	yes
0520			**Looking for work/setting up business in service activities in household enterprise**				
	05200	052000	Looking for work in service activities in household enterprise	SB	1.50	yes	yes
0530			**Travel related to providing services for income**				
	05300	053000	Travel related to providing services for income	n/a	n/a	n/a	n/a
0590			**Work for household providing services for income n.e.c.**				
	05900	059000	Work for household providing services for income n.e.c.	LPA	2.00	yes	no
0611			**Unpaid domestic services**				
	06111		Food management	LPA	2.50	yes	no
		061111	Preparing meals/snacks	LPA	2.50	yes	no
		061112	Serving meals/snacks	LPA	2.50	yes	no
		061113	Cleaning up after food preparation/meals/snacks	LPA	2.50	yes	no
		061119	Other specified activities related to food management	LPA	2.50	yes	no
		06111x	Food management n.f.d.	LPA	2.50	yes	no

ICATUS 2005 activity Code			Title	Category	MET	Wakefulness	Sitting/ lying
	06112		Cleaning and upkeep of dwelling and surroundings	MVPA	3.35	yes	no
		061121	Indoor cleaning	MVPA	3.30	yes	no
		061122	Outdoor cleaning	MVPA	4.00	yes	no
		061123	Recycling; disposal of garbage	LPA	2.50	yes	no
		061124	Care of outdoor garden, landscaping, trimming, grounds/yard/lawn maintenance	MVPA	4.15	yes	no
		061125	Heating and water supply (including tending furnaces, boilers and fire places)	MVPA	3.40	yes	no
		061126	Making various household arrangements	LPA	2.50	yes	no
		061129	Other specified activities related to cleaning and upkeep of dwelling and surroundings	MVPA	3.35	yes	no
		06112x	Cleaning and upkeep of dwelling and surroundings n.f.d.	MVPA	3.35	yes	no
	06113		Do-it-yourself decoration, maintenance and small repairs	MVPA	3.00	yes	no
		061131	Do-it-yourself improvement, maintenance and repair of dwellings	MVPA	3.30	yes	no
		061132	Installation, servicing and repair of personal and household goods	MVPA	3.00	yes	no
		061133	Vehicle maintenance and minor repairs	LPA	2.65	yes	no
		061139	Other specified activities related to do-it-yourself decoration, maintenance and small repairs	MVPA	3.00	yes	no
		06113x	Do-it-yourself decoration, maintenance and small repairs n.f.d.	MVPA	3.00	yes	no
	06114		Care of textiles and footwear	LPA	2.40	yes	no
		061141	Hand-washing; loading/unloading washing machine	MVPA	3.00	yes	no
		061142	Drying; hanging out, bringing in wash	MVPA	3.00	yes	no
		061143	Ironing/pressing	LPA	1.80	yes	yes
		061144	Sorting, folding, storing	LPA	2.15	yes	no
		061145	Mending/repairing and care of clothes; cleaning and polishing shoes	LPA	2.40	yes	yes
		061149	Other specified care of textiles and footwear	LPA	2.40	yes	no
		06114x	Care of textiles and footwear n.f.d.	LPA	2.40	yes	no
	06115		Household management	LPA	2.30	yes	yes
		061151	Paying household bills (utilities, cable television etc.)	LPA	2.30	yes	yes
		061152	Budgeting, organizing, planning	SB	1.50	yes	yes
		061153	Selling, disposing of household assets	LPA	2.30	yes	yes
		061159	Other specified household management	LPA	2.30	yes	yes
		06115x	Household management n.f.d.	LPA	2.30	yes	yes
	06116		Pet care	LPA	2.53	yes	no
		061161	Daily care including feeding, cleaning, grooming, walking	LPA	2.75	yes	no
		061162	Taking pets for veterinary care	LPA	2.30	yes	no
		061169	Other specified pet care	LPA	2.53	yes	no
		06116x	Pet care n.f.d.	LPA	2.53	yes	no
0612			**Shopping**				
	06121		Shopping for/purchasing of goods and related activities	LPA	2.00	yes	no
		061211	Shopping for/purchasing of consumer goods	LPA	2.30	yes	no
		061212	Shopping for/purchasing of durable/capital goods	LPA	1.80	yes	no
		061213	Window shopping	LPA	2.00	yes	no
		061219	Other specified shopping for/purchasing of goods and related activities	LPA	2.00	yes	no
		06121x	Shopping for/purchasing of goods and related activities n.f.d.	LPA	2.00	yes	no
	06122		Shopping for/availing of services and related activities	LPA	1.65	yes	yes

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		061221	Shopping for/availing of repair and maintenance services	LPA	1.80	yes	yes
		061222	Shopping for/availing of administrative services	LPA	1.65	yes	yes
		061223	Shopping for personal care services (not for oneself)	LPA	1.65	yes	yes
		061224	Shopping for medical and health-care services (not for oneself)	LPA	1.65	yes	yes
		061225	Shopping for/availing of childcare services	LPA	1.65	yes	yes
		061226	Shopping for educational services	LPA	1.65	yes	yes
		061229	Other specified shopping/availing of services	LPA	1.65	yes	yes
		06122x	Shopping for/availing of services and related activities n.f.d	LPA	1.65	yes	yes
0620			**Travel related to provision of unpaid domestic services**				
	06200	062000	Travel related to provision of unpaid domestic services	n/a	n/a	n/a	n/a
0690			**Unpaid domestic services n.e.c.**				
	06900	069000	Unpaid domestic services n.e.c.	LPA	2.45	yes	no
0711			**childcare**				
	07111		Caring for children/physical care	LPA	2.00	yes	no
		071111	General childcare	LPA	2.15	yes	no
		071112	Putting children to bed	SB	1.40	yes	yes
		071113	Getting children ready for school	LPA	2.50	yes	no
		071114	Giving personal care to children	LPA	2.00	yes	no
		071115	Giving medical/health-care to children	LPA	2.00	yes	no
		071119	Other specified physical care of children	LPA	2.00	yes	no
		07111x	Caring for children/physical care n.f.d.	LPA	2.00	yes	no
	07112		Teaching, training, helping children	LPA	2.20	yes	no
		071121	Teaching children	MVPA	3.00	yes	no
		071122	Reading, playing and talking with children	LPA	2.20	yes	no
		071123	Giving emotional support to children	LPA	1.75	yes	yes
		071129	Other specified teaching, training, helping activities	LPA	2.20	yes	no
	07113		Accompanying children to places	LPA	1.80	yes	no
		071131	Accompanying children to receive personal services	LPA	1.80	yes	no
		071132	Accompanying children to receive medical/health services	LPA	1.80	yes	no
		071133	Accompanying children to school, day-care centres	LPA	1.80	yes	no
		071134	Accompanying children to sports, lessons etc.	LPA	1.80	yes	no
		071135	Taking children on excursions, museum visits and similar outings; coordinating or facilitating child's social or non-school activities	LPA	2.00	yes	no
		071139	Accompanying children to other specified places	LPA	1.80	yes	no
		07113x	Accompanying children to places n.f.d.	LPA	1.80	yes	no
	07114	071140	Minding children (passive care)	SB	1.30	yes	yes
0712			**Adult care**				
	07121		Caring for adults/physical care	MVPA	3.00	yes	no
		071211	Giving personal care to adults	MVPA	3.00	yes	no
		071212	Giving medical/health-care to adults	MVPA	3.00	yes	no
		071219	Other specified physical care of adults	MVPA	3.00	yes	no
		07121x	Caring for adults/physical care n.f.d.	MVPA	3.00	yes	no
	07122	071220	Caring for adults/emotional support	SB	1.50	yes	yes
	07123		Accompanying adults to places	LPA	2.40	yes	no

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		071231	Accompanying adults to receive personal services	LPA	2.50	yes	no
		071232	Accompanying adults to receive medical/health services	LPA	2.50	yes	no
		071233	Accompanying adults for shopping	LPA	2.40	yes	no
		071234	Accompanying adults to social activities	LPA	2.25	yes	no
		071235	Accompanying adults to cultural, sports and entertainment venues	LPA	2.25	yes	no
		071239	Accompanying adults to other specified places	LPA	2.40	yes	no
		07123x	Accompanying adults to places n.f.d.	LPA	2.40	yes	no
0720			**Travel related to unpaid caregiving services to household members**				
	07200	072000	Travel related to unpaid caregiving services to household members	n/a	n/a	n/a	n/a
0790			**Providing unpaid caregiving services to household members n.e.c.**				
	07900	079000	Providing unpaid caregiving services to household members n.e.c.	LPA	2.00	yes	no
0811			**Unpaid help to other households**				
	08111		Household maintenance and management as help to other households	LPA	2.40	yes	no
		081111	Preparing and serving meals as help to other households	LPA	2.50	yes	no
		081112	Cleaning and upkeep as help to other households	MVPA	3.30	yes	no
		081113	Care of textiles as help to other households	LPA	2.30	yes	no
		081114	Household management as help to other households	LPA	2.30	yes	no
		081115	Pet care as help to other households	LPA	2.40	yes	no
		081119	Other specified help to other households	LPA	2.40	yes	no
		08111x	Household maintenance and management as help to other households n.f.d.	LPA	2.40	yes	no
	08112		Shopping for/purchasing of goods and services as help to other households	LPA	2.05	yes	no
		081121	Shopping for/purchasing of goods as help	LPA	2.30	yes	no
		081122	Shopping for/purchasing of services as help	LPA	1.80	yes	no
		081129	Other specified shopping/purchasing as help	LPA	2.05	yes	no
		08112x	Shopping for/purchasing of goods and services as help to other households n.f.d.	LPA	2.05	yes	no
	08113	081130	Construction, renovation and repairs of dwellings and other structures as help to other households	MVPA	4.00	yes	no
	08114	081140	Repairs of consumer and household goods as help to other households	LPA	2.75	yes	no
	08115	081150	Unpaid help in business/farm and employment as help to other households	LPA	2.30	yes	no
	08116	081160	Childcare as help to other households	LPA	2.50	yes	no
	08117	081170	Adult care as help to other households	MVPA	3.15	yes	no
	08118	081180	Transportation assistance to other households	LPA	2.50	yes	yes
0812			**Community-organized services**				
	08121	081210	Community organized work: cooking for collective celebrations etc.	LPA	2.50	yes	no
	08122	081220	Work on road/building repair, clearing and preparing community land, cleaning (streets, markets etc.)	MVPA	4.75	yes	no
	08123	081230	Organizing and work on community-based assistance to villages, other sublocations	LPA	1.90	yes	yes
	08124	081240	Organizing and work on community-based assistance to families and individuals	LPA	1.90	yes	yes
0813			**Organized unpaid volunteer services**				
	08131	081310	Volunteer work for organizations (not directly for individuals)	LPA	2.30	yes	yes
	08132	081320	Volunteer work through organizations (extended directly to individuals)	MVPA	3.00	yes	no
0820			**Attendance in meetings**				

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	08200	082000	Attendance in meetings	SB	1.50	yes	yes
0830			**Other community services**				
	08300		Involvement in civic and related responsibilities	LPA	2.30	yes	no
		083001	Attending civic ceremonies	LPA	2.00	yes	no
		083002	Attending to civic obligations	LPA	2.30	yes	no
		083009	Other specified involvement in civic and related responsibilities	LPA	2.30	yes	no
		08300x	Involvement in civic and related responsibilities n.f.d.	LPA	2.30	yes	no
0840			**Travel related to community services and help to other households**				
	08400	084000	Travel related to community services and help to other households	n/a	n/a	n/a	n/a
0890			**Community services and help to other households n.e.c.**				
	08900	089000	Community services and help to other households n.e.c.	LPA	2.45	yes	no
0911			**General education**				
	09111		School/university attendance	LPA	2.15	yes	yes
		091111	Attending class/lecture including taking examinations	SB	1.30	yes	yes
		091112	Engaging in co-curricular and extra-curricular activities	MVPA	3.00	yes	no
		091119	Other specified activities related to school/university attendance	LPA	2.15	yes	yes
		09111x	School/university attendance n.f.d.	LPA	2.15	yes	yes
	09112	091120	Breaks/waiting at place of general education	LPA	1.65	yes	no
	09113	091130	Self-study for distance education course work (video, audio, online)	SB	1.30	yes	yes
0912			**Homework, course review, research related to general education**				
	09120	091200	Homework, course review, research related to general education	SB	1.40	yes	yes
0913			**Additional study, non-formal education and courses during free time**				
	09130	091300	Additional study, non-formal education and courses during free time	SB	1.40	yes	yes
0914			**Career/professional development training and studies**				
	09140	091400	Career/professional development training and studies	LPA	1.65	yes	yes
0920			**Other activities carried out in relation to learning activities**				
	09200	092000	Other activities carried out in relation to learning activities	LPA	2.00	yes	no
0930			**Travel related to learning**				
	09300	093000	Travel related to learning	n/a	n/a	n/a	n/a
0990			**Learning activities n.e.c.**				
	09900	099000	Learning activities n.e.c.	LPA	1.65	yes	yes
1011			**Socializing and communication**				
	10111		Talking, conversing	SB	1.50	yes	yes
		101111	Talking/conversing face to face	SB	1.50	yes	yes
		101112	Talking/conversing by telephone, texting, short-wave radio etc	SB	1.50	yes	yes
		101113	Cyber-chatting including instant messaging, discussion groups etc.	SB	1.50	yes	yes
		101119	Other specified activities related to talking/conversing	SB	1.50	yes	yes
		10111x	Talking, conversing n.f.d.	SB	1.50	yes	yes
	10112		Socializing activities	LPA	1.90	yes	yes
		101121	Doing activities/going to places or events together	LPA	2.00	yes	no
		101122	Receiving visitors	LPA	1.80	yes	yes
		101123	Visiting friends and relatives	LPA	1.80	yes	yes

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		101124	Hosting parties, receptions, similar gatherings	LPA	1.80	yes	yes
		101125	Attending parties, receptions, similar gatherings	LPA	2.00	yes	yes
		101126	Socializing at bars, clubs	LPA	2.50	yes	no
		101129	Other specified socializing activities	LPA	1.90	yes	yes
		10112x	Socializing n.f.d.	LPA	1.90	yes	yes
	10113	101130	Reading and writing mail	SB	1.30	yes	yes
	10114	101140	Unsocial/antisocial/negative social activities	LPA	1.80	yes	no
	1011x		Socializing and communication n.f.d.	LPA	1.65	yes	yes
1012			**Participating in community cultural/social events**				
	10121	101210	Participating in community celebrations of cultural/historic events	LPA	1.80	yes	no
	10122	101220	Participating in community rites/events (non-religious) of weddings, funerals, births and similar rites-of-passage	LPA	1.80	yes	no
	10123	101230	Participating in community social functions (music, dance etc.)	LPA	2.00	yes	no
	1012x		Community participation n.f.d.	LPA	1.80	yes	no
1020			**Travel related to socializing and community participation**				
	10200	102000	Travel related to socializing and community participation	n/a	n/a	n/a	n/a
1090			**Socializing and community participation n.e.c.**				
	10900	109000	Socializing and community participation n.e.c.	LPA	1.80	yes	yes
1111			**Attendance at organized/mass cultural events**				
	11111	111110	Visit museum, art gallery, historical/cultural park, heritage site	MVPA	3.50	yes	no
	11112	111120	Attendance at movies/cinema	SB	1.50	yes	yes
	11113	111130	Attendance at theatre, opera, ballet, concerts	LPA	1.80	yes	yes
	11119	111190	Attendance at other specified mass cultural events	MVPA	3.50	yes	no
1112			**Attendance at parks/gardens, shows**				
	11120	111200	Attendance/visit to zoo, animal park, botanic garden, amusement centre, fairs, festivals, circus, animal shows, plant shows	MVPA	3.30	yes	no
1113			**Attendance at sports events**				
	11131	111310	Attendance at professional sports events	LPA	2.40	yes	yes
	11132	111320	Attendance at amateur sports events	LPA	2.40	yes	yes
1120			**Travel related to attending/visiting cultural, entertainment and sports events/venues**				
	11200	112000	Travel related to attending/visiting cultural, entertainment and sports events/venues	n/a	n/a	n/a	n/a
1190			**Attending/visiting sports, entertainment and cultural events/venues n.e.c.**				
	11900	119000	Attending/visiting sports, entertainment and cultural events/venues n.e.c.	LPA	2.40	yes	no
1211			**Visual, literary and performing arts (as hobby) and related courses**				
	12111	121110	Visual arts	LPA	2.75	yes	yes
	12112	121120	Literary arts	SB	1.30	yes	yes
	12113	121130	Performing arts (dance, music, theatre)	MVPA	4.00	yes	no
	1211x		Visual, literary and performing arts n.f.d.	LPA	2.75	yes	no
1212			**Technical hobbies and related courses**				
	12120	121200	Technical hobbies and related courses	LPA	2.80	yes	no
1213			**Playing games and other pastimes and related courses**				
	12131	121310	Solo games	LPA	2.90	yes	no
	12132	121320	Card games, board games	SB	1.50	yes	yes

ICATUS 2005 activity Code			Title	Category	MET	Wakeful ness	Sitting/ lying
	12133	121330	Computer games (including arcade and video games)	MVPA	3.05	yes	yes
	12134	121340	Social/group games	MVPA	5.00	yes	no
	12135	121350	Gambling	LPA	2.50	yes	yes
	1213x		Playing games and other pastimes n.f.d.	LPA	2.90	yes	yes
1220			**Travel related to hobbies, games and other pastimes**				
	12200	122000	Travel related to hobbies, games and other pastimes	n/a	n/a	n/a	n/a
1290			**Hobbies, games and other pastimes n.e.c.**				
	12900	129000	Hobbies, games and other pastimes n.e.c.	LPA	2.86	yes	yes
1311			**Participating in sports**				
	13111	131110	Walking and hiking; jogging and running	MVPA	5.05	yes	no
	13112	131120	Biking, skating, skateboarding	MVPA	7.00	yes	no
	13113	131130	Aerobics, yoga, weight-training and other fitness programmes	MVPA	3.50	yes	no
	13114	131140	Ball games, individual sports	MVPA	5.15	yes	no
	13115	131150	Ball games, team sports	MVPA	7.00	yes	no
	13116	131160	Water sports	MVPA	6.00	yes	no
	13117	131170	Winter/ice/snow sports	MVPA	7.00	yes	no
	13118	131180	Contact sports	MVPA	7.80	yes	no
1312			**Camping and other outdoor activities**				
	13121	131210	Camping	LPA	2.50	yes	no
	13122	131220	Horseback-riding	MVPA	5.80	yes	yes
	13123	131230	Pleasure drives; sightseeing	LPA	2.00	yes	yes
1320			**Travel related to indoor and outdoor sports participation and related courses**				
	13200	132000	Travel related to indoor and outdoor sports participation and related courses	n/a	n/a	n/a	n/a
1390			**Indoor and outdoor sports participation and related courses n.e.c.**				
	13900	139000	Indoor and outdoor sports participation and related courses n.e.c.	MVPA	5.80	yes	no
1411			**Reading**				
	14111	141110	Reading books	SB	1.30	yes	yes
	14112	141120	Reading periodicals	SB	1.30	yes	yes
	14119	141190	Reading other specified materials	SB	1.30	yes	yes
	1411x		Reading n.f.d.	SB	1.30	yes	yes
1412			**Watching/listening to television and video**				
	14121		Watching/listening to television	SB	1.15	yes	yes
		141211	Watching/listening to television (regular programming)	SB	1.15	yes	yes
		141212	Watching/listening to television (time-shifted programming)	SB	1.15	yes	yes
		141219	Other specified activities related to watching/listening to television	SB	1.15	yes	yes
		14121x	Watching/listening to television n.f.d.	SB	1.15	yes	yes
	14122		Watching/listening to video programmes	SB	1.15	yes	yes
		141221	Watching/listening to rented/purchased movies	SB	1.50	yes	yes
		141222	Watching/listening to rented/purchased video programmes other than movies	SB	1.15	yes	yes
		141229	Other specified activities related to watching/listening to video	SB	1.15	yes	yes
		14122x	Watching/listening to video programmes n.f.d.	SB	1.15	yes	yes
1413			**Listening to radio and audio devices**				

ICATUS 2005 activity				Category	MET	Wakeful ness	Sitting/ lying
Code			Title				
	14131	141310	Listening to radio programmes	SB	1.40	yes	yes
	14132	141320	Listening to other audio media	SB	1.40	yes	yes
	1413x		Listening to radio and audio devices n.f.d.	SB	1.40	yes	yes
1414			**Using computer technology**				
	14141	141410	Using computer technology for reading	SB	1.30	yes	yes
	14142	141420	Using computer technology for video/audio	SB	1.25	yes	yes
	14143	141430	Surfing the Internet; downloading, uploading	SB	1.30	yes	yes
	1414x		Using computer technology n.f.d.	SB	1.30	yes	yes
1420			**Visiting library**				
	14200	142000	Visiting library	LPA	1.80	yes	yes
1430			**Travel related to mass media**				
	14300	143000	Travel related to mass media	n/a	n/a	n/a	n/a
1490			**Mass media n.e.c.**				
	14900	149000	Mass media n.e.c.	SB	1.33	yes	yes
1511			**Sleep and related activities**				
	15111	151110	Night sleep/essential sleep	Sleep	0.95	no	yes
	15112	151120	Incidental sleep/naps	Sleep	0.95	no	yes
	15113	151130	Sleeplessness	SB	1.30	yes	yes
	1511x		Sleep and related activities n.f.d.	Sleep	0.95	no	yes
1512			**Eating and drinking**				
	15121		Eating meals/snack	SB	1.50	yes	yes
		151211	Eating a meal (including drinks taken with meal)	SB	1.50	yes	yes
		151212	Eating a snack (including drinks taken with snack)	SB	1.50	yes	yes
	15122	151220	Drinking other than with meal or snack	LPA	1.65	yes	yes
	1512x		Eating and drinking n.f.d.	LPA	1.58	yes	yes
1513			**Personal hygiene and care**				
	15131	151310	Personal hygiene and care	LPA	2.00	yes	no
	15132	151320	Health/medical care to oneself	SB	1.30	yes	yes
1514			**Receiving personal and health/medical care from others**				
	15141	151410	Receiving personal care from others	SB	1.30	yes	yes
	15142	151420	Receiving health/medical care from others	SB	1.30	yes	yes
1515			**Religious activities**				
	15151	151510	Private prayer, meditation, and other informal spiritual activities	SB	1.30	yes	yes
	15152	151520	Participating in religious activities (formal practice of religion)	LPA	2.00	yes	yes
1516			**Activities associated with resting, relaxing**				
	15161	151610	Doing nothing; resting, relaxing	SB	1.30	yes	yes
	15162	151620	Smoking	SB	1.30	yes	yes
	15163	151630	Reflecting/meditating, thinking, planning	SB	1.30	yes	yes
1520			**Travel related to personal care and maintenance activities**				
	15200	152000	Travel related to personal care and maintenance activities	n/a	n/a	n/a	n/a
1590			**Personal care and maintenance activities n.e.c.**				
	15900	159000	Personal care and maintenance activities n.e.c.	SB	1.30	yes	yes

Notes: MET: metabolic equivalent of task; n.f.d.: not further defined; n.e.c.: not elsewhere classified; SB: sedentary behaviour, LPA: light physical activity, MVPA: moderate-to-vigorous physical activity; n/a: not applicable

Appendix VII: ICATUS 2016

Appendix VII Metabolic equivalent (MET) values, summary codes and movement categories assigned to International Classification of Activities for Time Use Statistics (ICATUS) 2016 activities

ICATUS 2016 activity Code		Title	Category	MET	Wakeful-ness	Sitting /lying
11		**Employment in corporations, government and non-profit institutions**				
	110	Employment in corporations, government and non-profit institutions	n/a	n/a	n/a	n/a
12		**Employment in household enterprises to produce goods**				
	121	Growing of crops for the market in household enterprises	MVPA	3.55	yes	no
	122	Raising animals for the market in household enterprises	MVPA	4.30	yes	no
	123	Forestry and logging for the market in household enterprises	MVPA	3.90	yes	no
	124	Fishing for the market in household enterprises	MVPA	4.15	yes	no
	125	Aquaculture for the market in household enterprises	MVPA	4.30	yes	no
	126	Mining and quarrying for the market in household enterprises	MVPA	5.50	yes	no
	127	Making and processing goods for the market in household enterprises	MVPA	3.00	yes	no
	128	Construction activities for the market in household enterprises	MVPA	4.50	yes	no
	129	Other activities related to employment in household enterprises to produce goods	LPA	2.03	yes	no
13		**Employment in households and household enterprises to provide services**				
	131	Vending and trading of goods in household enterprises	LPA	2.50	yes	no
	132	Providing paid repair, installation, maintenance and disposal in households and household enterprises	MVPA	3.00	yes	no
	133	Providing paid business and professional services in households and household enterprises	SB	1.50	yes	yes
	134	Transporting goods and passengers for pay or profit in households and household enterprises	LPA	2.50	yes	yes
	135	Providing paid personal care services in households and household enterprises	LPA	2.15	yes	no
	136	Providing paid domestic services	LPA	2.23	yes	no
	139	Other activities related to employment in households and household enterprises providing services	LPA	2.03	yes	no
14		**Ancillary activities and breaks related to employment**				
	141	Activities ancillary to employment	LPA	1.65	yes	yes
	142	Breaks during working time within employment	SB	1.30	yes	yes
15		**Training and studies in relation to employment**				
	150	Training and studies in relation to employment	LPA	2.40	yes	yes
16		**Seeking employment**				
	160	Seeking employment	SB	1.40	yes	yes
17		**Setting up a business**				
	170	Setting up a business	LPA	1.65	yes	yes
18		**Travelling and commuting for employment**				
	181	Employment-related travel	n/a	n/a	n/a	n/a
	182	Commuting	n/a	n/a	n/a	n/a
21		**Agriculture, forestry, fishing and mining for own final use**				
	211	Growing crops and kitchen gardening, for own final use	MVPA	3.55	yes	no
	212	Farming of animals and production of animal products, for own final use	MVPA	4.30	yes	no
	213	Hunting, trapping and production of animal skins, for own final use	MVPA	3.30	yes	no
	214	Forestry and logging, for own final use	MVPA	3.50	yes	no
	215	Gathering wild products, for own final use	MVPA	3.50	yes	no

ICATUS 2016 activity Code	Title	Category	MET	Wakeful-ness	Sitting /lying
216	Fishing, for own final use	MVPA	4.15	yes	no
217	Aquaculture, for own final use	MVPA	4.30	yes	no
218	Mining and quarrying, for own final use	MVPA	5.50	yes	no
22	**Making and processing goods for own final use**				
221	Making, processing food products, beverages and tobacco for own final use	LPA	2.67	yes	no
222	Making, processing textiles, wearing apparel, leather and related products, for own final use	MVPA	3.00	yes	yes
223	Making, processing of wood and bark products, for own final use	MVPA	3.30	yes	no
224	Making, processing bricks, concrete slabs, hollow blocks, tiles for own final use	MVPA	4.75	yes	no
225	Making, processing herbal and medicinal preparations for own final use	SB	1.40	yes	yes
226	Making, processing metals and metal products for own final use	MVPA	4.50	yes	no
227	Making, processing of products using other materials for own final use	LPA	3.00	yes	no
229	Acquiring supplies and disposing of products and other activities related to making and processing goods for own final use	LPA	2.03	yes	no
23	**Construction activities for own final use**				
230	Construction activities for own final use	MVPA	4.30	yes	no
24	**Supplying water and fuel for own household or for own final use**				
241	Gathering firewood and other natural products used as fuel for own final use	MVPA	3.50	yes	no
242	Fetching water from natural and other sources for own final use	MVPA	4.30	yes	no
25	**Travelling, moving, transporting or accompanying goods or persons related to own-use production of goods**				
250	Travelling, moving, transporting or accompanying goods or persons related to own-use production of goods	n/a	n/a	n/a	n/a
31	**Food and meals management and preparation**				
311	Preparing meals/snacks	LPA	2.50	yes	no
312	Serving meals/snacks	LPA	2.50	yes	no
313	Cleaning up after food preparation/meals/snacks	LPA	2.50	yes	no
314	Storing, arranging, preserving food stocks	MVPA	3.00	yes	no
319	Other activities related to food and meals management and preparation	LPA	2.50	yes	no
32	**Cleaning and maintaining of own dwelling and surroundings**				
321	Indoor cleaning	MVPA	3.30	yes	no
322	Outdoor cleaning	MVPA	4.00	yes	no
323	Recycling and disposal of garbage	LPA	2.50	yes	no
324	Upkeep of in/outdoor plants, hedges, garden, grounds, landscape, etc.	MVPA	4.15	yes	no
325	Tending furnace, boiler, fireplace for heating and water supply	MVPA	3.40	yes	no
329	Other activities related to cleaning and upkeep of dwelling and surroundings	LPA	2.50	yes	no
33	**Do-it-yourself decoration, maintenance and repair**				
331	Do-it-yourself improvement, maintenance and repair of own dwelling	MVPA	3.30	yes	no
332	Installation, servicing and repair of personal and household goods including ICT equipment	MVPA	3.00	yes	no
333	Vehicle maintenance and repairs	LPA	2.65	yes	no
339	Other activities related to do-it-yourself decoration, maintenance and repair	MVPA	3.00	yes	no
34	**Care and maintenance of textiles and footwear**				
341	Hand/machine-washing	MVPA	3.00	yes	no
342	Drying; hanging out, bringing in wash	MVPA	3.00	yes	no
343	Ironing/pressing/folding	LPA	1.98	yes	no
344	Mending/repairing and care of clothes and shoes; cleaning and polishing shoes	LPA	2.40	yes	yes
349	Other activities related to care of textiles and footwear	LPA	2.40	yes	no

Code	ICATUS 2016 activity Title	Category	MET	Wakeful-ness	Sitting /lying
35	**Household management for own final use**				
351	Paying household bills	LPA	2.30	yes	yes
352	Budgeting, planning, organizing duties and activities in the household	SB	1.50	yes	yes
359	Other activities related to household management	LPA	2.30	yes	yes
36	**Pet care**				
361	Daily pet care	LPA	2.75	yes	no
362	Using veterinary care or other pet care services (grooming, stabling, holiday or day care)	LPA	2.30	yes	no
369	Other activities related to pet care	LPA	2.53	yes	no
37	**Shopping for own household and family members**				
371	Shopping for/purchasing of goods and related activities	LPA	2.00	yes	no
372	Shopping for/availing of services and related activity	LPA	1.65	yes	yes
38	**Travelling, moving, transporting or accompanying goods or persons related to unpaid domestic services for household and family members**				
380	Travelling, moving, transporting or accompanying goods or persons related to unpaid domestic services for household and family members	n/a	n/a	n/a	n/a
39	**Other unpaid domestic services for household and family members**				
390	Other unpaid domestic services for household and family members	n/a	n/a	yes	no
41	**Childcare and instruction**				
411	Caring for children including feeding, cleaning, physical care	LPA	2.08	yes	no
412	Providing medical care to children	LPA	2.00	yes	no
413	Instructing, teaching, training, helping children	LPA	2.20	yes	no
414	Talking with and reading to children	LPA	1.98	yes	yes
415	Playing and sports with children	MVPA	3.15	yes	no
416	Minding children (passive care)	SB	1.30	yes	yes
417	Meetings and arrangements with schools and child care service providers	SB	1.50	yes	yes
419	Other activities related to childcare and instruction	LPA	2.10	yes	no
42	**Care for dependent adults**				
421	Assisting dependent adults with tasks of daily living	MVPA	3.00	yes	no
422	Assisting dependent adults with medical care	MVPA	3.00	yes	no
423	Assisting dependent adults with forms, administration, accounts	SB	1.30	yes	yes
424	Affective/emotional support for dependent adults	SB	1.50	yes	yes
425	Passive care of dependent adult	SB	1.30	yes	yes
426	Meetings and arrangements with adult care service providers	SB	1.50	yes	yes
429	Other activities related to care for dependent adults	MVPA	3.00	yes	no
43	**Help to non-dependent adult household and family members**				
431	Feeding, cleaning, physical care for non-dependent adult household and family members including for temporary illness	MVPA	3.00	yes	no
432	Affective/emotional support for non-dependent adult household and family members	SB	1.50	yes	yes
439	Other activities related to care for non-dependent adult household and family members	MVPA	3.00	yes	no
44	**Travelling and accompanying goods or persons related to unpaid caregiving services for household and family members**				
441	Travelling related to care-giving services for household and family members	n/a	n/a	n/a	n/a
442	Accompanying own children	LPA	1.80	yes	no
443	Accompanying dependent adults	LPA	2.40	yes	no
444	Accompanying non-dependent adult household and family members	LPA	2.40	yes	no
49	**Other activities related to unpaid caregiving services for household and family members**				

ICATUS 2016 activity Code	Title	Category	MET	Wakeful-ness	Sitting /lying
490	Other activities related to unpaid caregiving services for household and family members	LPA	2.00	yes	no
51	**Unpaid direct volunteering for other households**				
511	Unpaid volunteer household maintenance, management, construction, renovation and repair	MVPA	3.35	yes	no
512	Unpaid volunteer shopping/purchasing goods and services	LPA	2.05	yes	no
513	Unpaid volunteer childcare and instruction	LPA	2.04	yes	no
514	Unpaid volunteer care for adults	SB	1.50	yes	yes
515	Unpaid volunteer unpaid help in enterprises owned by other households	LPA	2.30	yes	no
519	Other activities related to direct unpaid volunteering for other households	LPA	2.50	yes	no
52	**Unpaid community- and organization-based volunteering**				
521	Unpaid volunteer work on road/building repair, clearing and preparing land, cleaning (streets, markets, etc.), and construction	MVPA	4.75	yes	no
522	Unpaid volunteer preparing/serving meals, cleaning up	LPA	2.50	yes	no
523	Unpaid volunteer cultural activities, recreation and sports activities	MVPA	3.00	yes	no
524	Unpaid volunteer office/administrative work	LPA	2.30	yes	yes
529	Other activities related to community- and organization-based unpaid volunteering	LPA	2.50	yes	no
53	**Unpaid trainee work and related activities**				
530	Unpaid trainee work and related activities	n/a	n/a	n/a	n/a
54	**Travelling time related to unpaid volunteer, trainee and other unpaid work**				
540	Travelling time related to unpaid volunteer, trainee and other unpaid work	n/a	n/a	n/a	n/a
59	**Other unpaid work activities**				
590	Other unpaid work activities	LPA	2.45	yes	no
61	**Formal education**				
611	School/university attendance	SB	1.30	yes	yes
612	Extra-curricular activities	MVPA	3.00	yes	no
613	Breaks at place of formal education	LPA	1.65	yes	no
614	Self-study for distance education course work (video, audio, online)	SB	1.30	yes	yes
619	Other activities related to formal education	LPA	2.15	yes	yes
62	**Homework, being tutored, course review, research and activities related to formal education**				
620	Homework, being tutored, course review, research and activities related to formal education	SB	1.40	yes	yes
63	**Additional study, non-formal education and courses**				
630	Additional study, non-formal education and courses	SB	1.40	yes	yes
64	**Travelling time related to learning**				
640	Travelling time related to learning	n/a	n/a	n/a	n/a
69	**Other activities related to learning**				
690	Other activities related to learning	LPA	2.00	yes	no
71	**Socializing and communication**				
711	Talking, conversing, chatting	SB	1.50	yes	yes
712	Socializing/getting together/gathering activities	LPA	1.90	yes	yes
713	Reading and writing mail (including email)	SB	1.30	yes	yes
719	Other activities related to socializing and communication	LPA	1.80	yes	no
72	**Participating in community cultural/social events**				
721	Participating in community celebrations of cultural/historic events	LPA	1.80	yes	no
722	Participating in community rites/events (non-religious) of weddings, funerals, births and similar rites-of-passage	LPA	1.80	yes	no
723	Participating in community social functions (music, dance, etc.)	LPA	2.00	yes	no

Code	ICATUS 2016 activity Title	Category	MET	Wakeful-ness	Sitting /lying
729	Other activities related to community participation	LPA	1.80	yes	no
73	**Involvement in civic and related responsibilities**				
730	Involvement in civic and related responsibilities	LPA	2.30	yes	no
74	**Religious practices**				
741	Private prayer, meditation and other spiritual activities	SB	1.30	yes	yes
742	Participating in collective religious practice	LPA	2.00	yes	yes
749	Other activities related to religious practice	LPA	1.65	yes	yes
75	**Travelling time related to socializing and communication, community participation and religious practice**				
750	Travelling time related to socializing and communication, community participation and religious practice	n/a	n/a	n/a	n/a
79	**Other activities related to socializing and communication, community participation and religious practice**				
790	Other activities related to socializing and communication, community participation and religious practice	LPA	1.80	yes	yes
81	**Attending/visiting cultural, entertainment and sports events/venues**				
811	Attendance at organized/mass cultural events, and shows	MVPA	3.30	yes	no
812	Attendance at parks/gardens	MVPA	3.30	yes	no
813	Attendance at sports events	LPA	2.40	yes	yes
819	Other activities related to attendance at cultural, entertainment and sports events	LPA	1.80	yes	yes
82	**Cultural participation, hobbies, games and other pastime activities**				
821	Visual, literary and performing arts (as hobby)	LPA	2.75	yes	no
822	Hobbies	LPA	2.40	yes	no
823	Playing games and other pastime activities	LPA	2.90	yes	yes
829	Other activities related to cultural participation, hobbies, games	LPA	2.00	yes	no
83	**Sports participation and exercise and related activities**				
831	Participating in sports	MVPA	6.50	yes	no
832	Exercising	MVPA	6.50	yes	no
84	**Mass media use** *				
841	Reading for leisure	SB	1.30	yes	yes
842	Watching/listening to television and video	SB	1.15	yes	yes
843	Listening to radio and audio devices	SB	1.40	yes	yes
849	Other activities related to mass media use	SB	1.30	yes	yes
85	**Activities associated with reflecting, resting, relaxing**				
850	Activities associated with reflecting, resting, relaxing	SB	1.30	yes	yes
86	**Travelling time related to culture, leisure, mass-media and sports practices**				
	Travelling time related to culture, leisure, mass-media and sports practices	n/a	n/a	n/a	n/a
89	**Other activities related to culture, leisure, mass-media and sports practices**				
890	Other activities related to culture, leisure, mass-media and sports practices	LPA	1.80	yes	no
91	**Sleep and related activities**				
911	Night sleep/essential sleep	Sleep	0.95	no	yes
912	Incidental sleep/naps	Sleep	0.95	no	yes
913	Sleeplessness	SB	1.30	yes	yes
919	Other sleep and related activities	Sleep	0.95	no	yes
92	**Eating and drinking**				
921	Eating meals/snack	SB	1.50	yes	yes
922	Drinking other than with meal or snack	LPA	1.65	yes	yes

Code	ICATUS 2016 activity Title	Category	MET	Wakeful-ness	Sitting /lying
93	**Personal hygiene and care**				
931	Personal hygiene and care	LPA	2.00	yes	no
932	Health/medical care to oneself	SB	1.30	yes	yes
939	Other activities related to personal hygiene and care	LPA	1.65	yes	no
94	**Receiving personal care and health/medical care from others**				
941	Receiving personal care from others	SB	1.30	yes	yes
942	Receiving health/medical care from others	SB	1.30	yes	yes
949	Other activities related to receiving personal and health/medical care	SB	1.30	yes	yes
95	**Travelling time related to self-care and maintenance activities**				
950	Travelling time related to self-care and maintenance activities	n/a	n/a	n/a	n/a
99	**Other self-care and maintenance activities**				
990	Other self-care and maintenance activities	SB	1.30	yes	yes

Notes: MET: metabolic equivalent of task; n.f.d.: not further defined; n.e.c.: not elsewhere classified; SB: sedentary behaviour, LPA: light physical activity, MVPA: moderate-to-vigorous physical activity; n/a: not applicable; * the collection of the contextual variable “Using an ICT device” is recommended.

Appendix VIII: MVPA for additional health benefits

Appendix VIII Meeting the moderate-to-vigorous physical activity guideline for additional health benefits: population prevalence and associations with sociodemographic variables

Sociodemographic variable	**Percentage (95% CI)**					**Adjusted OR (95% CI)**				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Total (*n*)	66.7 (66.3 - 67.2)	82.7 (82.3 - 83.0)	81.0 (80.6 - 81.3)	74.3 (73.9 - 74.7)	0.152**					
Sex										
Male	69.3 (68.7 – 70.0)	85.3 (84.8 - 85.8)	84.4 (83.9 - 84.9)	77.6 (77.1 - 78.15)	0.095**	Ref				
Female	64.1 (63.5 - 64.8)	80.0 (79.4 - 80.5)	77.7 (77.1 - 78.2)	71.1 (70.5 - 71.7)	0.827*	0.85 (0.81 - 0.89)	0.80 (0.76 - 0.85)	0.70 (0.67 - 0.74)	0.75 (0.72 - 0.79)	0.531*
Age										
18 - 29	60.6 (59.8 - 61.4)	78.4 (77.7 - 79.1)	75.5 (74.8 - 76.2)	69.98 (68.2 - 69.8)	0.791*	Ref				
30 - 39	67.6 (66.7 - 68.5)	83.4 (82.7 - 84.1)	79.7 (79.0 - 80.5)	72.2 (71.4 - 73.0)	0.994*	1.20 (1.13 - 1.28)	1.13 (1.04 - 1.22)	1.19 (1.12 - 1.28)	1.04 (0.98 - 1.11)	0.617*
40 - 49	70.7 (69.7 - 71.6)	86.8 (86.1 - 87.5)	85.4 (84.8 - 86.0)	77.84 (77.1 - 78.6)	0.112**	1.30 (1.21 - 1.39)	1.49 (1.37 - 1.63)	1.72 (1.60 - 1.86)	1.26 (1.18 - 1.34)	0.897*
50 - 59	74.1 (72.9 - 75.2)	84.7 (83.8 - 85.7)	85.3 (84.6 - 86.0)	79.0 (78.2 - 79.8)	0.005**	1.54 (1.42 - 1.67)	1.32 (1.20 - 1.46)	1.79 (1.65 - 1.95)	1.32 (1.23 - 1.42)	0.787*

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Household area										
Urban	48.2 (47.3 - 49.1)	73.8 (73.0 - 74.5)	73.7 (73.0 - 74.4)	68.8 (68.2 - 69.4)	0.094**	Ref				
Rural	75.7 (75.2 - 76.2)	87.3 (86.9 - 87.7)	84.4 (84.0 - 84.8)	79.1 (78.6 - 79.7)	0.988*	2.09 (1.98 - 2.21)	1.54 (1.44 - 1.66)	1.35 (1.27 - 1.43)	1.27 (1.21 - 1.34)	0.039*
Region										
Bangkok	40.3 (38.8 - 41.7)	65.8 (64.5 - 67.1)	64.4 (63.0 - 65.7)	59.8 (58.6 - 60.9)	0.157**	Ref				
Central	59.4 (58.3 - 60.4)	79.2 (78.4 - 80.1)	75.9 (75.1 - 76.7)	70.1 (69.4 - 70.9)	0.719*	1.18 (1.08 - 1.28)	1.41 (1.29 - 1.54)	1.50 (1.38 - 1.63)	1.37 (1.28 - 1.47)	0.646*
North	73.6 (72.6 - 74.6)	88.5 (87.8 - 89.3)	87.0 (86.3 - 87.7)	82.4 (81.6 - 83.3)	0.211**	1.88 (1.71 - 2.06)	2.68 (2.40 - 2.99)	3.04 (2.76 - 3.36)	2.65 (2.44 - 2.88)	0.302*
North-East	77.3 (76.5 – 78.0)	87.9 (87.3 - 88.5)	85.2 (84.7 - 85.8)	79.9 (79.2 - 80.7)	0.947*	2.28 (2.09 - 2.48)	2.39 (2.16 - 2.64)	2.67 (2.44 - 2.92)	2.21 (2.05 - 2.39)	0.937*
South	67.9 (66.5 - 69.2)	86.1 (85.1 - 87.1)	84.6 (83.7 - 85.5)	79.6 (78.4 - 80.5)	0.177**	1.46 (1.32 - 1.61)	2.07 (1.83 - 2.33)	2.55 (2.30 - 2.83)	2.14 (1.96 - 2.33)	0.240*
Marital status										
Never married	58.2 (57.2 - 59.2)	76.8 (76.0 - 77.7)	75.6 (74.8 - 76.4)	69.1 (68.3 - 69.9)	0.129**	Ref				

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Married	70.0 (69.4 - 70.6)	84.9 (84.4 - 85.3)	82.7 (82.3 - 83.1)	76.5 (76.0 - 77.0)	0.210**	0.94 (0.88 - 0.99)	1.08 (1.01 - 1.16)	1.06 (0.99 - 1.12)	1.05 (1.00 - 1.11)	0.724*
Formerly married	63.8 (61.8 - 65.8)	81.0 (79.4 - 82.7)	81.7 (80.4 - 83.1)	74.5 (73.1 - 75.9)	0.021**	0.72 (0.64 - 0.81)	0.89 (0.78 - 1.02)	1.05 (0.94 - 1.18)	0.95 (0.87 - 1.04)	0.399*
Religion										
Buddhist	66.4 (66.0 - 66.9)	82.5 (82.1 - 82.9)	80.8 (80.5 - 81.2)	74.1 (73.7 - 74.5)	0.152**	Ref				
Non-Buddhist	72.5 (70.5 - 74.6)	85.4 (83.8 - 87.1)	84.0 (82.4 - 85.5)	78.4 (76.7 - 80.1)	0.156**	1.43 (1.27 - 1.60)	1.17 (1.01 - 1.37)	1.29 (1.14 - 1.46)	1.17 (1.04 - 1.31)	0.656*
Employment status										
Employed	69.5 (69.0 - 70.0)	86.1 (85.7 - 86.4)	83.6 (83.3 - 84.0)	76.7 (76.3 - 77.1)	0.213**	Ref				
Unemployed	53.8 (52.5 - 55.0)	66.7 (65.6 - 67.8)	67.9 (66.9 - 69.0)	64.0 (63.1 - 65.0)	0.390*	0.59 (0.55 - 0.62)	0.38 (0.36 - 0.41)	0.48 (0.46 - 0.51)	0.57 (0.54 - 0.60)	0.740*
Highest education level										
None	74.2 (71.7 - 76.6)	80.1 (77.8 - 82.4)	77.8 (76.0 - 79.6)	70.6 (69.3 - 71.9)	0.391*	Ref				

Sociodemographic variable	Percentage (95% CI)					Adjusted OR (95% CI)				
	2001	2004	2009	2015	*p*-value	2001	2004	2009	2015	*p*-value
Primary	75.5 (75.0 - 76.1)	86.4 (86.0 - 86.9)	84.5 (84.0 - 85.0)	80.6 (80.0 - 81.2)	0.816*	1.01 (0.88 - 1.16)	1.36 (1.16 - 1.59)	1.32 (1.18 - 1.48)	1.51 (1.4 - 1.63)	0.288*
Secondary	54.8 (53.8 - 55.8)	78.4 (77.6 - 79.2)	78.3 (77.6 - 79.0)	72.3 (71.6 - 73.1)	0.084**	0.57 (0.49 - 0.65)	1.22 (1.03 - 1.43)	1.25 (1.11 - 1.41)	1.18 (1.09 - 1.27)	0.069**
Higher education	44.1 (42.6 - 45.6)	77.1 (75.9 - 78.3)	76.5 (75.6 - 77.4)	69.0 (68.2 - 69.9)	0.108**	0.39 (0.33 - 0.45)	1.08 (0.91 - 1.28)	1.31 (1.16 - 1.48)	1.21 (1.12 - 1.31)	0.004**
Unspecified	52.6 (41.7 - 63.4)	68.2 (60.0 - 76.4)	80.1 (72.8 - 87.5)	63.3 (57.2 - 69.3)	0.001**	0.58 (0.36 - 0.94)	0.87 (0.57 - 1.34)	1.29 (0.81 - 2.14)	0.82 (0.63 - 1.08)	0.677*

Legend: CI = confidence interval; OR = odds ratio; ref = reference group; * = linear model; ** = quadratic model

Appendix IX: Published Papers

Appendix IX Published Papers

- Physical Activity and Sedentary Behaviour Research in Thailand: A Systematic Scoping Review
- Do Thai People Meet Recommended Physical Activity Level?: the 2015 National Health and Welfare Survey (in Thai)
- Correlates of Physical Activity and Sedentary Behaviour in the Thai Population: A Systematic Review
- Standardised criteria for classifying the International Classification of Activities for Time-Use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity

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RESEARCH ARTICLE

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Physical activity and sedentary behaviour research in Thailand: a systematic scoping review

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Abstract

Background: The number of deaths per year attributed to non-communicable diseases is increasing in low- and middle-income countries, including Thailand. To facilitate the development of evidence-based public health programs and policies in Thailand, research on physical activity (PA) and sedentary behaviour (SB) is needed. The aims of this scoping review were to: (i) map all available evidence on PA and SB in Thailand; (ii) identify research gaps; and (iii) suggest directions for future research.

Methods: A systematic literature search was conducted through 10 bibliographic databases. Additional articles were identified through secondary searches of reference lists, websites of relevant Thai health organisations, Google, and Google Scholar. Studies written in Thai or English were screened independently by two authors and included if they presented quantitative or qualitative data relevant to public health research on PA and/or SB.

Results: Out of 25,007 screened articles, a total of 564 studies were included in the review. Most studies included PA only (80%), 6.7% included SB only, and 13.3% included both PA and SB. The most common research focus was correlates (58.9%), followed by outcomes of PA/SB (22.2%), prevalence of PA/SB (12.4%), and instrument validation (3.2%). Most PA/SB research was cross-sectional (69.3%), while interventions (19.7%) and longitudinal studies (2.8%) were less represented. Most studies (94%) used self-reports of PA/SB, and few (2.5%) used device-based measures. Both sexes were examined in most studies (82.5%). Adults were the main target population group (51.1%), followed by older adults (26.9%), adolescents (15.7%), and children (6.3%). Clinical populations were investigated in the context of PA/SB in a relatively large number of studies (15.3%), most frequently those with cardiovascular disease, diabetes, and hypertension (22%, 21%, and 21% respectively).

Conclusions: The number of Thai papers on PA published per year has been increasing, indicating a growing interest in this research area. More studies using population-representative samples are needed, particularly among children and adolescents, and investigating SB as a health risk factor. To provide stronger evidence on determinants and outcomes of PA/SB, longitudinal studies using standardised measures of PA and SB are required.

Keywords: Physical activity, Sedentary behaviour, Scoping review, Thailand

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Background

Deaths caused by non-communicable diseases (NCDs), such as cardiovascular disease and cancer, are common worldwide. Global rates of deaths attributed to NCDs increased from 60% in 2000 to 70% in 2015 [1]. Importantly, the rates of mortality caused by NCDs are increasing faster in low- and middle-income countries than in high-income countries [1]. In Thailand, NCD mortality rates increased from 64% in 2000 to 71% in 2015 [1]. Strong evidence has shown positive impacts of physical activity (PA) on the prevention of NCDs [2–5]. Some evidence also suggests that excessive sedentary behaviour (SB) (e.g. sitting) may increase the risk of several common NCDs, independently of PA [6]. It should be noted, however, that recent methodological papers questioned the independence of PA and SB, based on the argument that these behaviours are co-dependent parts of a time-use composition [7–9]. Nevertheless, the prevalence of physical inactivity, defined as not meeting the recommended level of moderate-to-vigorous physical activity (MVPA) and excessive SB, defined as sitting or reclining with low energy expenditure for more than 7 hours/day, is still high across the world, particularly in middle- and high-income countries [10–12]. In 2012, it was estimated that nearly three-quarters of all physical inactivity-related deaths occurred in low- and middle-income countries [13]. In Thailand, it was estimated that 6.3% of total mortality cases could be attributable to physical inactivity in 2013 [14]. Although, no country-specific estimates are available for Thailand, global estimates suggest that excessive SB is responsible for 3.4% of all-cause mortality [12].

Thailand has been affected by urbanisation, where, in search of better socioeconomic opportunities, many young working people move to urban areas or cities, especially to the capital, Bangkok. According to the Department of Economic and Social Affairs, United Nations, half of the Thai population (51.1%) is urban [13]. This increased rapidly from 1955 when only 18% of the Thai population lived in urban areas [13]. Many issues have arisen as a consequence of the increasing number of people living in the urban setting. An emerging concern related to urbanisation is the increasing time spent in SB in Thai population and its negative health outcomes [14]. In Thailand, there has been increasing focus on strategies to improve engagement in PA and reduce SB. Thailand has experienced significant economic development over the past four decades, moving from a low-income to upper-middle income economy [15]. Since 2002, Thailand has established a "Universal Health Coverage" scheme, to provide healthcare and financial protection to all Thai nationals [16].

As part of the national health promotion strategies, the Thai Government has aimed to promote engagement in PA since 1997 and has recently included targets to reduce SB as ways to reduce the burden of NCDs [17]. Moreover, a number of national actions have been taken to help achieve the World Health Organization's (WHO) 15-year global target, set in 2010, of 10% reduction in the prevalence of physical inactivity, defined as less than 60 minutes of MVPA daily for adolescents and 150 minutes of MVPA weekly for persons aged 18 and over [17, 18]. WHO has commended Thailand as the regional leader in developing national health policies to promote better health through increasing PA [19]. Many PA promoting initiatives and public campaigns were introduced in Thailand, such as the development of new cycle paths, marathons organised all over the country, and a weekly program of aerobic exercise at workplace launched and led by the Prime Minister of Thailand [17, 19, 20]. Further, the national strategies and guidelines for increasing PA and reducing SB were developed [21]. Despite initiatives to increase the Thai population's engagement in PA, population-based studies suggest that the prevalence of physical inactivity has increased from 18.5% in 2008 [22] to 19.2% in 2014 [23]. This suggests that the development and implementation of effective public health programs and policies to promote PA and decrease SB is needed.

In PA and SB epidemiology, a number of literature reviews have been conducted. For example, reviews have examined worldwide patterns of PA and SB, and show a shift from physically active to sedentary lifestyles [24–26]. Other reviews have examined factors associated with PA and SB, and the efficacy of interventions to influence the behaviours, especially in high-income countries [27–33]. However, most previous literature reviews are restricted to English language studies only and, therefore, studies from many low- and middle-income countries, including Thailand, have typically not been included. Furthermore, many previous reviews on PA and SB are restricted to specific, narrow topics (e.g. environmental determinants of PA) [27]. A comprehensive assessment of epidemiological evidence on PA and SB in the Thai context is lacking. To provide directions for future studies informing public health policies and actions targeted to increase PA and reduce SB, it is important to map the available evidence on epidemiology of PA and SB in Thailand. Scoping reviews have shown to be a useful method for a systematic assessment of the current body of evidence in a broad subject area [34]. In this study, we conducted a systematic scoping review to assess previous Thai PA and SB research, to identify research gaps and provide evidence-based directions for future research on PA and SB in Thailand to guide the development of strategies and policies.

Methods

Search strategy

This scoping review was conducted according to the Guidance for Conducting Systematic Scoping Reviews [35]. It included primary and secondary database searches. The primary literature search was conducted from database inception to September 2016 through the following bibliographic databases: Academic Search Premier; CINAHL; Health Source: Nursing/Academic Edition; MasterFILE Premier; PsycINFO; PubMed/MEDLINE; Scopus; SPORTDiscus; Web of Science (including Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Conference Proceedings Citation Index- Science, and Conference Proceedings Citation Index- Social Science & Humanities); and the Networked Digital Library of Theses and Dissertations (NDLTD). PubMed/MEDLINE, Scopus and Web of Science databases were searched using their own search engines, whilst other databases were searched through EBSCOhost. The search was conducted through titles, abstracts, and keywords of the indexed publications. The detailed search strategies, including the full search syntaxes, used for each database can be found in Additional file 1.

Additional articles and grey literature documents were identified via secondary literature searching through: (i) the reference lists of all articles selected in the primary search; (ii) websites of ten relevant Thai public health institutions and organizations, including the Division of Physical Activity, Ministry of Public Health; Thai Health Promotion Foundation; Physical Activity Research Centre; Health Systems Research Institute; Thai NCD Network; Thai National Research Repository; Thai Thesis Database; and three university sources including Institute for Population and Social Research, Mahidol University; Chulalongkorn University Intellectual Repository; and Kasetsart University Research and (iii) Google and Google Scholar.

Study selection and inclusion criteria

All references from the primary database search were imported in EndNote X7 software (Thompson Reuters, San Francisco, CA, USA). After removing duplicates, the references were screened independently by two authors (NL and KS). The discrepancies between the study selections were resolved in discussion and consensus with a third author (ZP).

Studies were included in the present review, if they: (i) targeted any population group living in Thailand; (ii) conducted research on PA, physical inactivity, and/or SB; (iii) presented any quantitative or qualitative data relevant to public health, including but not limited to the levels, prevalence, correlates, determinants, or outcomes of engagement in PA and/or SB; or described the development or performed an evaluation of a PA and/or SB measurement tool or intervention; (iv) used any type of PA and/or SB measure, such as self-reports or device-based measures; (v) were written in Thai or English; and (vi) published as a journal article, conference paper, conference abstract, Master's thesis, Doctoral thesis, or report. Studies were excluded, if they: targeted non-Thai populations; had the primary outcome(s) focusing on sports/exercise performance, or physical therapy; and were published as literature reviews, commentaries, and editorials.

Data extraction

The following data were extracted from the included studies: (i) general bibliographical information, including author names, publication year, title, publication type, full text availability, language of full text, abstract availability, and language of abstract; (ii) description of research methods, including study design, survey method, sample size, and sampling method; (iii) information about the study population, including sex, age, municipality (rural/urban), region, and other specific characteristics of participants; (iv) description of measures, including the type of PA/SB measure, device model or questionnaire name, domains included (such as work, transport, and leisure-time), information about whether the measure has been validated or not (if applicable), and intervention type (if applicable); and (v) information about the study objectives. The detailed data extraction table for studies used in the review is available in Additional file 2.

Results

Search results

The flow diagram depicting the search and study selection processes can be found in Fig. 1. A total of 25,007 records were screened for inclusion. Of these, 8,389 studies were identified through primary searches, where, after removing duplicates, the titles and abstracts of 5,875 and full texts of 402 articles were screened. The secondary search yielded 16,618 results, of which 238 articles were selected. Overall, a total of 564 studies were included for review [36–598].

Bibliographic characteristics of included studies

All papers included in this review were published between 1987 and 2016. The number of papers published per year has increased over time (Fig. 2). English was the primary language used in the majority of Thai PA/SB papers full texts (67.4%), whilst nearly all papers (n = 546) had at least an English abstract (Fig. 3). Furthermore, 17% of full-text articles and 10.1% of abstracts were not available online, and, therefore, other means were used to access the publications (e.g. authors' contacts and

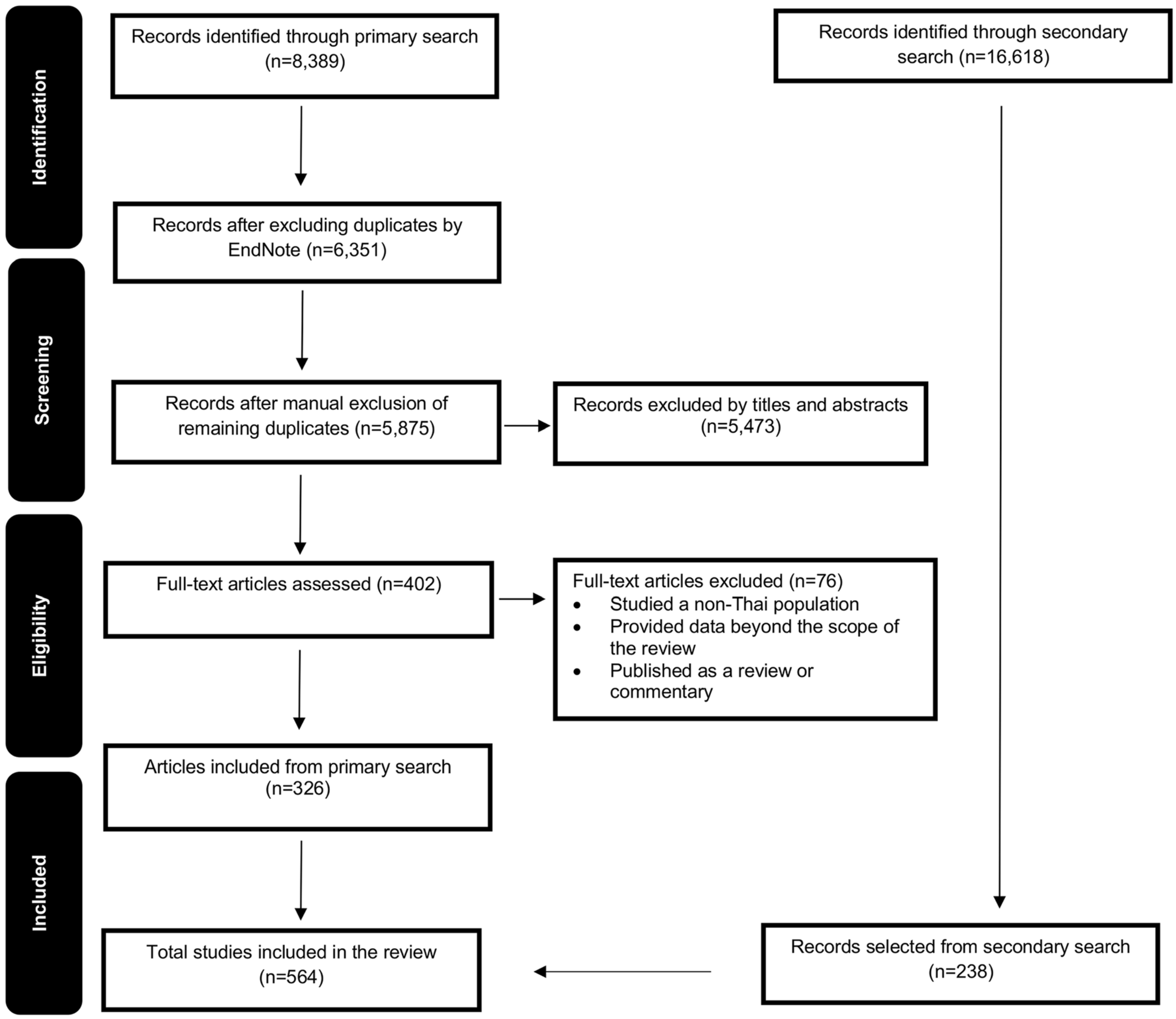

Fig. 1 Flow diagram of study selection process

request through university libraries). Most studies were peer-reviewed journal articles (68.3%), followed by theses (19.9%), conference papers (6.6%), and reports (5.3%).

Study characteristics

In 363 of 564 included studies (64.4%), PA and/or SB were the primary focus of the research (e.g. a study on correlates of PA), whilst the remaining studies were not strictly focused on PA and/or SB but were analysed among multiple other variables as key explanatory or outcome variables together with PA and/or SB (e.g. other lifestyle characteristics such as smoking). Eighty percent of the studies included PA only, 6.7% included SB only, and 13.3% included both PA and SB. Most studies focused on correlates of PA/SB (58.9%), followed by outcomes of PA/SB (22.2%), prevalence of PA/SB (12.4%), and instrument validation (3.2%). 69.3% of studies used cross-sectional designs. Less represented were intervention trials (19.7%), case-control studies (3.7%), longitudinal studies (2.8%), and measurement studies (2.3%). The majority of studies used quantitative methods (87.9%), with only 4.6% and 7.5% utilising qualitative methods or mixed-methods, respectively. In most studies, the data was collected using self-administered surveys (56.7%) or face-to-face interviews (31.4%) (Fig. 4). The sample sizes of the studies ranged from 6 to 113,882 and 7.8% of the studies were conducted using nationally representative samples. Among the studies in nationally representative samples, 29.5% were secondary data analyses of the following national surveys: National Health Examination Survey; National Elderly Survey; Thailand Global School-Based Student Health Survey; 2007 National Physical Activity and Obesity Survey; and 2010 Evaluation of Health

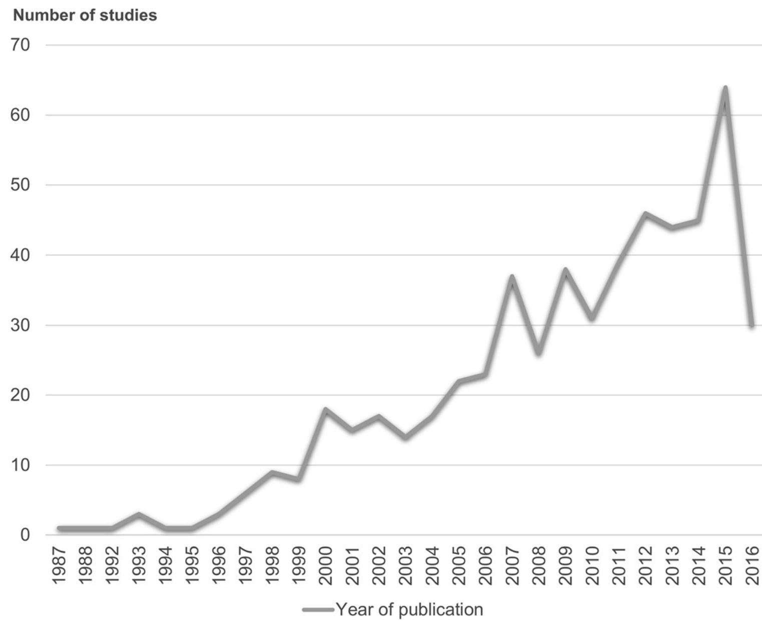

Fig. 2 The number of Thai studies on physical activity and sedentary behaviour published per year

Promotion and Sports in Regions. There were seven government reports on PA and/or SB levels presenting results from population-based studies, such as the Health and Welfare Survey 2015 conducted by the National Statistical Office and National Health Examination Survey conducted by the National Health Examination Survey Office.

Characteristics of study samples

Participants of both sexes were included in 82.5% of studies. Studies of females only (15.4%) were more common than studies of males only (2.1%). Adults (18-59 years) were the most frequently investigated age group (51.1%), followed by older adults (60+ years; 26.9%), adolescents (10 to 17 years; 15.7%), children (4 to 9 years;

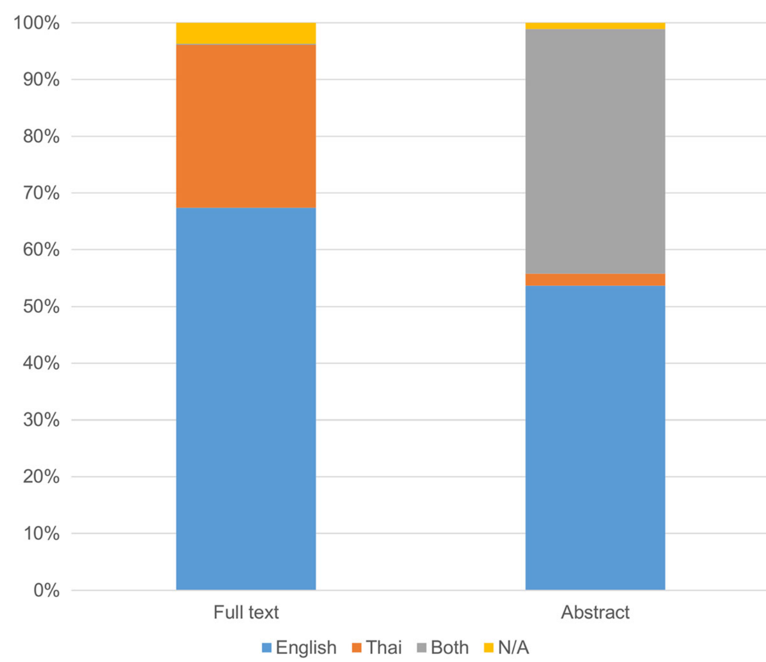

Fig. 3 Languages used in full-texts and abstracts of Thai physical activity and sedentary behaviour publications

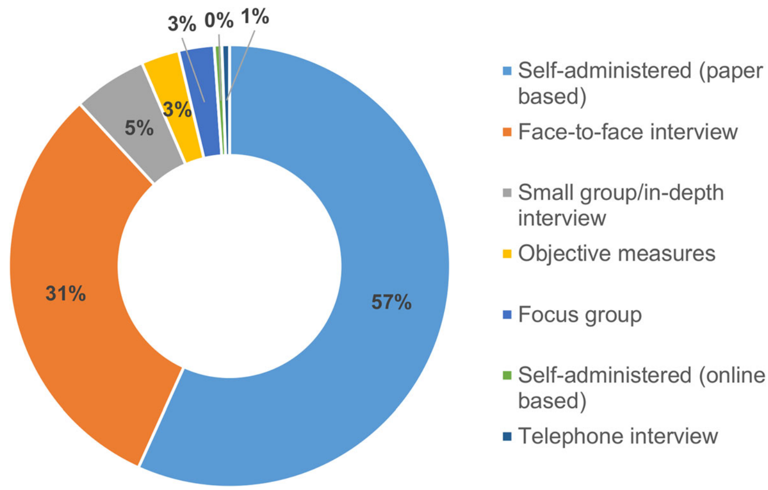

Fig. 4 Measures of physical activity and sedentary behaviour used in Thai studies

5.4%), and infants/toddlers (0 to 3 years; 0.9%). A large majority of studies were conducted in non-clinical populations (84.7%). Of these, 28.5% were conducted among primary-school, secondary-school, high-school, and university students. Employees in health-related professions, including nurses, physicians, and health-care students such as medical residents were participants in 9.8% of studies. Other specific occupations were represented in 6.5% of studies; most common among them were farmers, military personnel, university staff, and office workers. Some studies (2.1%) were conducted among employees in specific organizations, such as the Electricity Generating Authority of Thailand, Metropolitan Waterworks, and the Teachers Council. Other specific non-clinical populations included in the studies were, for instance, people with low or high level of PA or SB regularity (5.6%), obese/overweight people (3.8%), women before or in menopause (2.9%), pregnant women (1.3%), and tobacco smokers (0.4%). Clinical populations were also examined in the context of PA/SB (17.7%). Patients with cardiovascular disease, diabetes, and hypertension were among the most frequently observed groups (22%, 21%, and 21%, respectively). Hip/knee problems (13%) and cancers (6%) were also clinical conditions of interest (Table 1). By geographical distribution, Bangkok the capital was the most studied area (28.8%) and the Southern region was the least studied area (15.2%).

Measures of physical activity and sedentary behaviour

Out of 526 studies that investigated PA, most relied on self-reports only (73.4%) and 2.1% used both self-report and device-based measures. In nearly all of these studies (97.2%) PA was assessed using self-reported or proxy-reported questionnaires, and in most cases it was not specified which questionnaire or questionnaire item(s) were used for this purpose. The Global Physical Activity Questionnaire (GPAQ) and the International Physical Activity Questionnaire (IPAQ) were used in 25 (6.5%) and 23 studies (6%), respectively. Other self-reports were PA diary and logbook used in 14 studies (3.5%). Device-based measurement was used in 23 studies (4.4%), with accelerometer (n = 10) and pedometer (n = 9) being the most common devices. A large proportion of PA studies focused on exercise only (49.6%) or on total PA (32.5%). Domain-specific PA levels, including leisure-time, household, work-related, and transport PA, were examined in isolation in 2.5% of all PA studies. The most commonly studied domain of PA was leisure time (n = 16). Walking, as a type-specific PA, was investigated independently in 5 studies. In total, 5.9% of studies assessed a combination of domain- and type-specific PA levels, including exercise, sport and walking.

A total of 113 studies examined SB. Questionnaires were the most common measure of SB (91.2%), followed by activity diaries (4.4%), and device-based tools (3.5%). Most studies (65.5%) did not specify which questionnaires they used. GPAQ, IPAQ, and accelerometers were used in eight, four, and two studies, respectively. Screen time - including TV viewing, computer use, videogames, and internet/social networking - was the most commonly investigated type-specific SB (59.3%). Total sedentary or sitting time was assessed in 37 studies (32.7%), while SB in work and leisure-time domains was assessed in seven and five studies respectively.

Study topics

Correlates of PA and/or SB were the most common topic and were investigated in 58.9% of studies. We

Table 1 Population groups studied in Thai physical activity and sedentary behaviour research

Population groups	No. of studies
Non-clinical populations	
Students	136
General (no specific characteristics)	135
Occupation-specific populations	31
Groups based on PA/SB participation	27
Health-care students	27
Health-care professionals	20
Obese/overweight	18
Pre/post-menopausal women	14
Employees of a specific organization	10
Multiple populations groups	10
Pregnant and postpartum women	6
Ageing population	5
Religious groups	4
Smokers/non-smokers/ex-smokers	2
Others	19
Total	464
Clinical populations (general characteristic)	
Cardiovascular disease	22
Diabetes	21
Hypertension	21
Hip/knee injury/condition	13
Cancer	6
Respiratory disease/condition	4
Parkinson's disease	3
Diabetes and hypertension	2
Epilepsy	2
Dementia	1
Total	100

identified 11 groups of PA/SB correlates. The most common were: socio-demographic correlates, such as, age, gender, and education level (24%); psychological correlates, such as mental health and well-being, self-efficacy, social behaviours, and cognitive tasks (20.9%); physical health and functioning correlates including physiological and biological functions, diseases, and health problems (19.8%); and social and cultural correlates, such as social support, beliefs, and social practices (11.4%). Other reported correlates included: health behaviours and lifestyles; physical environment; general health; physical skills, abilities, and fitness; academic performance; knowledge; and policy (Table 2).

In total, 125 (22.2%) of the selected studies examined outcomes of PA and/or SB. Most of these studies examined physical health and functioning (33.8%), psychological outcomes (21.8%), physical skills, abilities, and fitness (19.4%), and health behaviours and lifestyles (14.8%). Other reported outcomes included general health; mortality; social characteristics; environmental characteristics; and knowledge (Table 2).

A number of measures were tested for validity and reliability in the Thai context (6.7%). These were mostly questionnaires (92.1%) such as GPAQ, IPAQ (short version), Godin-Shephard Leisure-Time Physical Activity Questionnaire (GSLTPAQ), Modifiable Activity Questionnaire for Adolescents (MAQA), and Perceived Benefits to Physical Activity Scale (PBEPAS). Two studies evaluated measurement properties of device-based measures of PA (pedometer and heart rate monitors). In one study [159] the Compendium of Physical Activities [599] was translated and validated.

Discussion

This study is the first systematic scoping review that summarises current evidence of Thai PA and SB research to support national directions in promoting healthy lifestyle through PA. We identified a large number of PA and SB studies conducted in Thailand, covering a broad range of topics, and using a variety of study designs. There was an increase in the number of Thai PA and SB studies published per year, from one study in 1987 to 64 studies in 2015 (the search was conducted up to September 2016), indicating a growing interest in this research area.

The first Thai publication focusing on PA that we identified was a doctoral thesis from 1987 [289], however the vast majority of PA studies were published in the last two decades. Importantly, the number of Thai papers on PA published per year has been increasing (Fig. 2), indicating that this area of research is developing. It is important to note that half of the studies on PA focused on exercise only, overlooking other types of PA (such as occupational PA, household PA, transport-related PA, and leisure-time PA other than exercise). Historically, the terms 'physical activity' and 'exercise' have been used interchangeably, and exercise has been one of the most commonly studied types of PA [600]. However, exercise is only one out of several various specific types of PA that may be important for health. From the public health perspective, it is important to study not only exercise but also other types of PA. In Thailand, the term "exercise" had been more widely used until the "physical activity" term was formally promoted in 2002, when the national focal point was changed from the Exercise Unit to the Division of Physical Activity and Health [17].

This finding for Thai studies is consistent with global trends in PA research over the last few decades. The

Table 2 Number of studies investigating correlates and outcomes of physical activity and sedentary behaviour in Thai populations

Categories	Correlates		Outcomes	
	No. of studies	%	No. of studies	%
Socio-demographic	162	24	-	-
General health	37	5.5	9	4.2
Physical health and functioning	134	19.8	73	33.8
Physical skills, abilities, and fitness	10	1.5	42	19.4
Psychological	141	20.9	47	21.8
Health behaviours and lifestyle	35	5.2	32	14.8
Social and culture	77	11.4	2	0.9
Physical environment	38	5.6	1	0.5
Academic/school performance	8	1.2	-	-
Mortality	-	-	2	0.9
Knowledge	27	4.0	8	3.7
Policy	6	0.9	-	-
Total*	675	100	216	100

Note: *Multiple correlates and/or outcomes were investigated in some studies; hence the sum of the totals is greater than the total number of included studies

proportion of studies using total MVPA (and not just exercise) as a measure of PA has increased in the last decade [49, 67, 230, 231, 432]. To align with Thai national recommendations on total MVPA, this trend in gathering evidence should be continued in future studies. Importantly, we did not locate any Thai population-based study that considered participation in muscle-strengthening activities, which is similar to the situation in most other countries [601, 602]. Given that Thai national PA guidelines for adults include a separate recommendation on participation in muscle-strengthening activities [603], this suggests more studies on this specific type of PA are needed.

Up until the present, studies on SB in Thailand were less represented than those on PA. SB research is a more recent field of inquiry, compared with PA epidemiology. It has only been in the past two decades that SB has been recognised as a risk factor independent of PA level [604–607]. It was therefore expected that in Thailand SB research would be less developed than PA research. Of the 113 studies addressing SB, 40 looked at specific types of SB, such as TV viewing, computer/internet use, and playing video games. The earliest Thai study we identified that examined type-specific SB, was conducted in 1994, as part of a doctoral thesis focusing on TV viewing and academic achievement [99]. The first study assessing total SB was conducted in 2000, again as part of a doctoral thesis [434]. Since then, there has been a steady increase in the number of Thai papers on SB published per year, indicating an increasing recognition of the importance of this area of research. Given the prevalence of SB and its potential negative health outcomes [6, 12], it is important that future studies continue to focus on SB in Thai populations.

Recent methodological developments have led to the establishment of a new discipline, called time-use epidemiology, where periods of time spent in PA, SB and sleep are no longer considered as independent risk factors, but instead are treated as mutually exclusive and exhaustive parts of the 24-hour day [7–9]. The new approach allows for drawing conclusions about how different reallocations of time between PA, SB and sleep affect health, and for finding the optimal balance of these components of time-use for good health [9, 608]. In line with the new developments and with the public health guidelines adopted in other countries [609–611], the most recent Thai guidelines on movement/non--movement behaviours included recommendations on PA, SB, and sleep [603]. However, the current review found no Thai studies aligned with this new approach, suggesting that this might be an area worth exploring in future epidemiological studies in Thailand.

Almost 70% of all included studies (PA and SB) used cross-sectional designs, whilst the evidence base on determinants and outcomes of PA/SB from longitudinal studies and intervention trials is less developed, potentially due to affordability-related reasons. However, a limitation of cross-sectional data is that they do not allow to draw conclusions about the direction of analysed relationships. To get a better insight into potential causes and consequences of PA and SB, longitudinal studies and controlled intervention trials are needed. Most studies in Thailand assessed PA and/or SB using self-reports. Despite the limitations of self-report instruments [612], these are still the predominant measure of PA and SB in population-based surveys internationally [613, 614]. The use of device-based measures of PA and SB, such as accelerometers, in large-scale epidemiological studies is becoming more affordable, especially in high-income countries [615–617]. However, device-based measurement of PA and/or SB was seldom used in the Thai context. This is likely due to issues related to the high cost and participant burden associated with device-based measurement of PA and SB [614]. Although device-based measuring has limitations in assessing domain- and type-specific PA and SB levels, it may provide some data that cannot be reliably assessed by existing questionnaires (e.g. timing of different activities during a day, detailed data on weekly distribution of PA). To better understand patterns of PA and SB in Thai populations, future research might benefit from employing device-based measures alongside self-report measures.

Although studies included in this review used a variety of sampling methods and a broad range of sample sizes, few were conducted in large-scale population-representative samples. Besides national surveys funded by the Thai government using large scale data samples, such as National Health Examination Survey, Thailand Physical Activity Children Survey, National Physical Activity and Obesity Survey, and Health and Welfare Survey, 10 other studies also utilized a large scale sample (n range: 24,743 – 87,143) from the Sukhothai Thammathirat Open University cohort. To improve the generalisability of findings from observational studies, the use of such large, nationally representative samples should be encouraged in future Thai PA and SB research.

Across age categories, young to middle aged adults (18-59 years) were the most commonly studied population group, followed by older adults (60+ years). The convenience of conducting research among adults and older adults, compared with research among children and adolescents, in terms of ethical considerations, ease of access to participants, and simplicity of measurement, may partially explain why most Thai PA and SB studies focused on these age groups. Another reason may be that adulthood and older age are more convenient stages to observe health impacts of PA and SB, as symptoms of many diseases rarely occur in younger population groups [618]. However, in addition to a number of topics in PA and SB research that are specific for children and adolescent populations (e.g. levels and patterns of school-based PA and SB, tracking of PA and SB from childhood to adolescence, association of PA and SB with educational outcomes in primary and secondary schools, effectiveness of PA and SB interventions in the school setting), findings among adults may not be generalizable to the populations of children and adolescents, which calls for more studies of these age groups in the future.

Thai PA and SB studies covered a wide range of topics, largely consistent with PA/SB research trends in middle- and high-income countries globally [5, 10, 12, 27]. However, there has been limited research on environmental correlates/determinants of PA and SB, associations between PA/SB and mortality outcomes, PA/SB policy research, and validation of device-based measures of PA/SB in different Thai population groups (e.g. across different sociodemographic groups). Around one-third of Thai PA/SB papers were published in the Thai language, while the remaining papers were published in English. Publications in English have higher visibility in the international scholarly context. Alternatively, publications in Thai may better inform local public health stakeholders, media and the general non-academic readership. Ideally, all publications would be in both languages, but in reality this is not feasible. It is, therefore, important to keep a balance between publishing in Thai and English, by always carefully considering the primary purpose of the paper and the targeted readership.

This systematic scoping review has several strengths. First, a systematic search and study selection strategy were applied to identify eligible studies. Comprehensiveness of the search was achieved by using a large number of relevant PA- and SB-related keywords, conducting primary search through 10 bibliographic databases, and supplementing this with an extensive secondary search. Second, data on 39 variables were extracted from the selected studies, which allowed for a detailed interpretation of the current situation in Thai PA and SB research. Last, a key strength was that, since both Thai and English language papers were included, we were able to review a large number of studies that might not have been captured if we only reviewed papers in one language.

This scoping review has some limitations. Although we tried to identify as many studies as possible, we may have missed some studies because they were not indexed in the selected databases. Furthermore, given the large total number of included studies, we focused on providing general recommendations, whilst an in-depth assessment of each individual study was not feasible. Future reviews are needed to summarise findings on specific topics in PA/SB epidemiology within the Thai context, particularly by different age groups (e.g. children, adolescents, adults, and older adults.

Summary recommendations for future research

Based on this systematic scoping review, it can be concluded that the greatest Thai PA/SB research gaps and limitations are: the lack of studies on SB; the use of unspecified and non-validated measures of PA and SB; a limited number of longitudinal studies; a limited number of studies conducted in population-representative samples; a limited number of studies conducted among children and adolescents; a limited coverage of several important PA/SB research topics, such as environmental factors. To provide stronger evidence and further improve the evidence base on PA and SB, future studies may consider several recommendations stemming from this review. First, given that SB research is less developed in the Thai context and that SB is emerging as a new and important health-risk factor among the Thai population [16], more studies on determinants of, outcomes of, and ways to reduce SB in the Thai population are needed. Future studies in Thailand would also be strengthened by using validated device-based and self-report measures of PA and SB. For a better understanding of determinants and outcomes of PA and SB in Thailand, future studies should aim to use longitudinal study designs. Additionally, to allow for better generalisation, more studies should use large, population-representative samples. Besides, future studies are needed specifically focusing on topics relevant to children and adolescents. Finally, research shows that PA is influenced by a number of individual, social, environmental, and policy factors [27, 619]. Whilst socio-demographic, psychological, and social correlates have been the topic of a number of Thai studies, more research is needed on environmental and policy-related correlates of PA and SB in Thailand.

Conclusions

Thai research on PA and SB has rapidly evolved and received increasing attention in the last two decades. Substantial literature was mapped in this review, showing that existing research has a great potential to support the development of healthy lifestyles by increasing PA and reducing SB in Thailand. However, current evidence could be strengthened, particularly by conducting more research on SB, using sound research methods, and covering the full range of research topics on determinants and outcomes of PA and SB. By following the recommendations provided in this systematic scoping review, future studies may provide even stronger evidence needed to inform public health efforts to promote PA and reduce SB in Thailand.

Additional files

Additional file 1: Search keywords. Detailed search keywords including the full search syntaxes used for each database. (PDF 183 kb)

Additional file 2: Data extraction table. The detailed table of all data extracted from each study included in this review. (XLSX 245 kb)

Abbreviations

GPAQ: Global Physical Activity Questionnaire; GSLTPAQ: Godin-Shephard Leisure-Time Physical Activity Questionnaire; IPAQ: International Physical Activity Questionnaire; MAQA: Modifiable Activity Questionnaire for Adolescents; MVPA: Moderate-to-Vigorous Physical Activity; NCDs: Non-Communicable Diseases; NDLTD: Networked Digital Library of Theses and Dissertations; PA: Physical Activity; PBEPAS: Perceived Benefits to Physical Activity Scale; SB: Sedentary Behaviour; WHO: World Health Organization

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Availability of data and materials

The summary of reviewed articles is available in Tables, Figures, and Additional files.

Authors' contributions

NL and ZP conceived the idea for the review. NL, ZP, SJHB and JAB conceptualised the review. NL took the lead in writing the study protocol. NL and ZP designed the systematic search strategies. NL and KS conducted the study selection. NL did the data extraction and analysed the data. NL drafted the initial manuscript. ZP, JAB, MC, SJHB, and KS contributed to writing the manuscript. All authors read and approved the final draft.

Ethics approval and consent to participate

Not applicable.

Competing interests

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คนไทยมีกิจกรรมทางกายเพียงพอตามเกณฑ์หรือไม่: ข้อมูลจากการสำรวจอนามัยและสวัสดิการ พ.ศ. 2558

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บทคัดย่อ การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาระดับการมีกิจกรรมทางกายที่เพียงพอ (adequate physical activity level) ในภาพรวมและจำแนกตามกลุ่มประชากรย่อยของประชากรไทยอายุตั้งแต่ 18 ปีขึ้นไป จากการสำรวจอนามัยและสวัสดิการ ปี พ.ศ. 2558 จำนวนกลุ่มตัวอย่าง 108,416 คน ด้วยสถิติเชิงพรรณนาและวิเคราะห์ ผลการศึกษาพบว่าประชากรไทยอายุตั้งแต่ 18 ปีขึ้นไป ร้อยละ 42.4 มีระดับกิจกรรมทางกายที่เพียงพอตามคำแนะนำขององค์การอนามัยโลก และร้อยละ 33.8 มีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก โดยกลุ่มที่มีระดับกิจกรรมทางกายที่เพียงพอสูง และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากต่ำ คือ ผู้ชาย ผู้ประกอบอาชีพด้านเกษตรกรรม ประมง ผู้ใช้แรงงาน และทำงานในโรงงาน และผู้ที่ไม่มีโรคประจำตัว ในทางตรงกันข้าม กลุ่มที่มีระดับกิจกรรมทางกายที่เพียงพอต่ำและมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากสูง คือ ผู้สูงอายุ ผู้ไม่ได้ทำงาน และผู้ที่มีโรคประจำตัว ข้อค้นพบจากการศึกษานี้มีประโยชน์ในการพัฒนานโยบายเพื่อลดพฤติกรรมเนือยนิ่งและเพิ่มกิจกรรมทางกายของคนไทย โดยเน้นการเพิ่มกิจกรรมทางกายในกลุ่มการทำงานและการเดินทาง และมุ่งเป้าไปที่กลุ่มที่มีระดับกิจกรรมทางกายที่เพียงพอต่ำ และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากที่สูง

คำสำคัญ: *กิจกรรมทางกาย, พฤติกรรมเนือยนิ่ง, การสำรวจอนามัยและสวัสดิการ, ประเทศไทย*

Abstract Do Thai People Meet Recommended Physical Activity Level?: The 2015 National Health and Welfare Survey

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**สำนักงานพัฒนานโยบายสุขภาพระหว่างประเทศ กระทรวงสาธารณสุข*
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This study aimed to determine the adequate physical activity level of Thai adults, and disaggregated by subgroups of participants. The study re-analyzed data of 108,416 Thai adults aged 18 and above from the 2015 National Health and Welfare Survey conducted by National Statistical Office. Descriptive and analytical statistics were defined in the analysis. The results showed that 42.4% of Thai adults aged 18 and above met physical activity level according to the recommendation by the World Health Organization and 33.8% had high level of physical inactivity. Most males, farmers and laborers, and those who had no underlying diseases, reached recommended physical activity level and had low-rate of high level of physical inactivity. On the other hand, most elderly, unemployed, and those who had underlying diseases, did not reach recommended physical activity level and had high-rate of high level of physical inactivity. Our findings will benefit to the national policy development to reduce sedentary behaviors and increase physical activity especially in work and transportation domains, with the focus on the subpopulations that did not reach the recommended physical activity level and had high level of physical inactivity.

Keywords: *physical activity, physical inactivity, sedentary behavior, Health and Welfare Survey, Thailand*

ภูมิหลังและเหตุผล

การมีกิจกรรมทางกายไม่เพียงพอเป็นปัจจัยเสี่ยงสำคัญต่อการเกิดโรคไม่ติดต่อเรื้อรัง องค์การอนามัยโลกประมาณการมีกิจกรรมทางกายไม่เพียงพอนำไปสู่การเสียชีวิตถึง 3.2 ล้านคนต่อปี[1-3] และเป็นสาเหตุการเสียชีวิตในประเทศไทยถึง 11,129 รายในปี พ.ศ. 2552[4]

องค์การอนามัยโลกจำแนกกิจกรรมทางกายตามกลุ่มกิจกรรมเป็น 3 กลุ่ม ได้แก่ (1) การทำงาน (activity at work) เช่น การทำงานบ้าน การทำงานที่เป็นอาชีพ (2) การเดินทางไปมายังที่ต่างๆ (transportation) โดยการเดินหรือขี่จักรยานไปทำงาน ไปวัดหรือไปตลาด และ (3) นันทนาการ (recreational activities) เช่น การเล่นกีฬาหลังเลิกงาน การเดินหรือขี่จักรยานเพื่อออกกำลัง นอกจากนี้ ยังมีอีกกลุ่มกิจกรรมที่มีการเคลื่อนไหวน้อย เรียกว่าพฤติกรรมเนือยนิ่ง (sedentary behavior) เช่น การนั่งดูโทรทัศน์ การนั่งอ่านหนังสือ การนั่งในรถระหว่างเดินทาง[3,5]

องค์การอนามัยโลกยังได้จำแนกความเข้มข้นของกิจกรรมทางกาย โดยอิงตามเกณฑ์ metabolic equivalent of task (MET) (1 MET มีค่าเท่ากับพลังงานที่ใช้ในการนั่งเฉยๆ หรือเท่ากับ 1 กิโลแคลอรี่/กิโลกรัม/ชั่วโมง) โดยการออกแรงระดับหนัก (8 MET) เช่น การยกของหนัก การขุดดิน การออกแรงระดับปานกลาง (4 MET) เช่น การยกของเบา การเดินเร็ว[3,5] และแนะนำระดับกิจกรรมทางกายที่เพียงพอสำหรับบุคคลอายุ 18 ปีขึ้นไป ที่การออกแรงระดับหนักเป็นเวลา 75 นาทีต่อสัปดาห์ และระดับปานกลางเป็นเวลา 150 นาทีต่อสัปดาห์ หรือเท่ากับ 600 MET-นาที ต่อสัปดาห์[3]

นอกจากนี้ ยังได้มีการจัดทำแบบสอบถามกิจกรรมทางกายระดับโลก (global physical activity questionnaire: GPAQ) โดยองค์การอนามัยโลก[5] เพื่อเป็นเครื่องมือในการเก็บข้อมูลกิจกรรมทางกายหรือการเคลื่อนไหวออกแรง/ออกกำลังในแต่ละประเทศ ซึ่งสถานการณ์ระดับกิจกรรมทางกายที่เพียงพอของประชากรโลก วัดโดยแบบสอบถาม GPAQ อยู่ที่ร้อยละ 66[3] และในประเทศไทยอยู่ที่ร้อยละ 78 ในปี 2546[6] ร้อยละ 85 ในปี 2550[7] ร้อยละ 82 ในปี 2551[8] ร้อยละ 66 ในปี 2555[9] และร้อยละ 68 ในปี 2556[10] และปี 2557[11] แตกต่างกันไปตามแต่ละการสำรวจ

องค์การสหประชาชาติได้กำหนด 9 เป้าหมายในการบรรลุการควบคุมและป้องกันโรคไม่ติดต่อเรื้อรังในปฏิญญาทางการเมืองเมื่อ พ.ศ. 2554 โดย 1 ใน 9 เป้าหมายกำหนดให้การลดระดับกิจกรรมทางกายไม่เพียง

พอลงร้อยละ 10 ภายใน พ.ศ. 2568 ซึ่งหากจะบรรลุ 9 เป้าหมายขององค์การสหประชาชาติในการควบคุมและป้องกันโรคไม่ติดต่อเรื้อรัง ประเทศไทยจะต้องมีระดับกิจกรรมทางกายที่เพียงพออยู่ที่ร้อยละ 84 ภายใน พ.ศ. 2568[12]

เมื่อพิจารณาระดับกิจกรรมทางกายของคนไทยในปีที่ผ่านๆ มา พบว่า มีความไม่คงที่ อาจเนื่องมาจากการเก็บข้อมูลทำโดยหลายหน่วยงานซึ่งมีระเบียบวิธีการสำรวจที่แตกต่างกัน ดังนั้นเพื่อให้การติดตามระดับกิจกรรมทางกายที่เพียงพอของประเทศไทยมีความชัดเจน สำนักงานสถิติแห่งชาติซึ่งเคยทำการสำรวจการออกกำลังกายของคนไทยอายุตั้งแต่ 11 ปีขึ้นไป เมื่อปี พ.ศ. 2546 จึงได้ใช้แบบสอบถาม GPAQ ในการสำรวจกิจกรรมทางกายเป็นครั้งแรกภายใต้การสำรวจอนามัยและสวัสดิการในปี พ.ศ. 2558 ซึ่งเป็นการสำรวจประชากรทั้งประเทศด้วยกลุ่มตัวอย่างจำนวนมากถึง 1.4 แสนคน

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาระดับกิจกรรมทางกายที่เพียงพอของประชากรไทย และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก โดยจำแนกตามกลุ่มประชากร เพื่อนำข้อมูลดังกล่าวมาใช้ประโยชน์ในการพัฒนานโยบายส่งเสริมกิจกรรมทางกายให้เหมาะสม อีกทั้งเป็นการติดตามผลการส่งเสริมกิจกรรมทางกายของประเทศไทย และการบรรลุ 9 เป้าหมายการควบคุมและป้องกันโรคไม่ติดต่อเรื้อรังขององค์การสหประชาชาติ

ระเบียบวิธีศึกษา

แหล่งข้อมูล : การศึกษานี้ใช้วิธีการวิเคราะห์ข้อมูลจากการสำรวจอนามัยและสวัสดิการ (สอส.) พ.ศ. 2558 เก็บข้อมูลระหว่างเดือนมีนาคมถึงเดือนเมษายน พ.ศ. 2558 โดยสำนักงานสถิติแห่งชาติ

รูปแบบการวิจัยและวิธีการเก็บข้อมูลประชากร : เป็นการสุ่มครัวเรือนตัวอย่างด้วยการสุ่มแบบสองขั้นตอน (stratified two stage sampling) ขั้นที่ 1 เลือกชุมนุมอาคาร/หมู่บ้าน ได้จำนวนตัวอย่างทั้งสิ้น 1,990 ชุมนุมอาคาร/หมู่บ้าน ขั้นที่ 2 เลือกครัวเรือนตัวอย่างจากครัวเรือนส่วนบุคคล จากบัญชีรายชื่อครัวเรือนซึ่งได้จากการนับจดในแต่ละชุมนุมอาคาร/หมู่บ้าน ด้วยวิธีการสุ่มแบบมีระบบ ได้ครัวเรือนตัวอย่าง 27,960 ครัวเรือน ได้ข้อมูลระดับบุคคลที่สามารถนำมาวิเคราะห์ทั้งสิ้น 139,848 คน โดยคำนวณและถ่วงน้ำหนักตามระเบียบวิธีทางสถิติเพื่อเป็นตัวแทนประชากรทั้งประเทศจำนวน 67,163,661 คน และใช้วิธีสัมภาษณ์สมาชิกที่อาศัยอยู่ในครัวเรือนส่วนบุคคลตัวอย่าง ทั้งในเขต-นอกเขตเทศบาลในทุกจังหวัด

กลุ่มตัวอย่างและตัวแปรที่ศึกษา : ประชากรที่ศึกษาเป็นประชากรไทยที่มีอายุตั้งแต่ 18 ปีขึ้นไป มีจำนวนทั้งสิ้น 108,416 คน ตัวแปรที่ใช้ในการวิเคราะห์ประกอบด้วย

1. ลักษณะทั่วไปของสมาชิกในครัวเรือน ได้แก่ เพศ อายุ ในเขต-นอกเขตเทศบาล ภาค การศึกษา อาชีพ และดัชนีทรัพย์สินครัวเรือน

2. กิจกรรมทางกาย ใช้แบบสอบถาม GPAQ ซึ่งแบ่งข้อคำถามตามกลุ่มกิจกรรมทางกาย ได้แก่ การทำงาน การเดินทาง นันทนาการ และพฤติกรรมเนือยนิ่ง กลุ่มการทำงานและนันทนาการแบ่งเป็นระดับความเข้มข้นของกิจกรรมทางกายเป็นระดับหนักและปานกลาง กลุ่มการเดินทาง เป็นระดับปานกลาง และกลุ่มพฤติกรรมเคลื่อนไหวน้อย ซึ่งสอบถามพฤติกรรมการนั่งและเอนกายในกิจกรรมต่างๆ ไม่รวมการนอนหลับ เช่น นั่งเล่นคอมพิวเตอร์ นั่งดูโทรทัศน์

3. มิติทางสุขภาพของประชากรกลุ่มตัวอย่าง โดยพิจารณาจาก (1) การมีโรคเรื้อรัง/โรคประจำตัว และ (2) การประเมินสถานะสุขภาพ ใน 5 ด้าน ได้แก่ การเคลื่อนไหว การดูแลตนเอง กิจกรรมที่ทำเป็นประจำ ความเจ็บป่วยหรือไม่สุขสบาย และความวิตกกังวลหรือซึมเศร้า โดยแบ่งระดับปัญหาสุขภาพเป็น 5 ระดับ คือ ไม่มีปัญหา มีปัญหาเล็กน้อย มีปัญหาปานกลาง มีปัญหา

มาก และไม่สามารถจะทำกิจกรรมด้านนั้นได้

แนวทางการวิเคราะห์ข้อมูล : ใช้โปรแกรม STATA/SE รุ่นที่ 13 ในการคำนวณทางสถิติ ประกอบด้วย 5 ขั้นตอนได้แก่

1. การวิเคราะห์ข้อมูลลักษณะทางประชากรและสังคมโดยใช้สถิติร้อยละและค่าเฉลี่ย จำแนกตามเพศ อายุ ที่อยู่ในเขต-นอกเขตเทศบาลและภาค ระดับการศึกษา อาชีพ และดัชนีทรัพย์สินครัวเรือน โดยถ่วงน้ำหนักตามการสุ่มตัวอย่าง

2. การคำนวณระดับกิจกรรมทางกายที่เพียงพอจากกิจกรรมทางกายระดับหนักและปานกลาง โดยระดับกิจกรรมทางกายที่เพียงพอ อิงตามเกณฑ์ที่องค์การอนามัยโลกแนะนำ คือ 600 MET-นาที/สัปดาห์ (3) มีขั้นตอนการคำนวณ ดังนี้

2.1 หาพลังงานจากกิจกรรมทางกายในแต่ละกลุ่มกิจกรรม (MET-นาที/สัปดาห์) = ความเข้มข้นของกิจกรรมทางกาย (MET) x ระยะเวลาที่ใช้ในแต่ละวัน (นาที) x จำนวนวันต่อสัปดาห์

2.2 หาผลรวมพลังงานจากกิจกรรมทางกายทุกกลุ่ม (กลุ่มการทำงาน+กลุ่มการเดินทาง+กลุ่มนันทนาการ)

2.3 หาระดับกิจกรรมทางกายที่เพียงพอ ด้วยการนำผลรวมพลังงานจากกิจกรรมทางกายทุกกลุ่ม หารด้วย 600 MET-นาที/สัปดาห์ (ตามค่าระดับกิจกรรมทางกายที่เพียงพอ ที่แนะนำโดยองค์การอนามัยโลก) โดยหากค่าที่ได้มากกว่าหรือเท่ากับ 1 ถือว่ามีระดับกิจกรรมทางกายที่เพียงพอ

ตัวอย่างการคำนวณ

หากผู้ตอบแบบสอบถามมีกิจกรรมทางกายในกลุ่มกิจกรรมการทำงานระดับหนัก 0 วัน/สัปดาห์ กลุ่มกิจกรรมการทำงานระดับปานกลาง 2 วัน/สัปดาห์ วันละ 10 นาที กลุ่มกิจกรรมการเดินทาง 5 วัน/สัปดาห์ วันละ 30 นาที กลุ่มกิจกรรมนันทนาการระดับหนัก 3 วัน/สัปดาห์ วันละ 20 นาที กลุ่มกิจกรรมนันทนาการระดับปานกลาง 3 วัน/สัปดาห์ วันละ 30 นาที แทนค่าในสูตรได้ดังนี้

ระดับกิจกรรมทางกายที่เพียงพอ = [(8 MET x 0 วัน/สัปดาห์ x 0 นาที) + (4 MET x 2 วัน/สัปดาห์ x 10 นาที) + (4 MET x 5 วัน/สัปดาห์ x 30 นาที) + (8 MET x 3 วัน/สัปดาห์ x 20 นาที) + (4 MET x 3 วัน/สัปดาห์ x 30 นาที)] / 600 MET-นาที/สัปดาห์

ระดับกิจกรรมทางกายที่เพียงพอ = 2.53 เท่า แปลความว่ากลุ่มตัวอย่างท่านนี้มีกิจกรรมทางกายเพียงพอ

ทั้งนี้ ได้กำหนดค่าระยะเวลาที่เป็นไปได้ในแต่ละกลุ่มกิจกรรม โดยสมมติฐานที่ว่ากลุ่มตัวอย่างอาจจะรายงานระยะเวลาที่ใช้ในบางกิจกรรมสูงหรือต่ำมากกว่าความเป็นจริง โดยกำหนดระยะเวลาสูงสุดในกลุ่มการทำงานที่ 12 ชั่วโมงต่อวัน กลุ่มการเดินทางและนันทนาการที่ 6 ชั่วโมงต่อวัน[13] และในกลุ่มพฤติกรรมเนือยนิ่งที่ 17 ชั่วโมงต่อวัน[14] และระยะเวลาต่ำสุดในแต่ละกลุ่มจะอยู่ที่ 0 นาทีต่อวัน

3. การวิเคราะห์แจกแจงระดับกิจกรรมทางกายที่เพียงพอ กับข้อมูลลักษณะทางประชากรและสังคมและสถานะสุขภาพ โดยใช้ค่าสถิติพรรณนา การแจกแจงนับ ร้อยละ และสมการถดถอยโลจิสติกแบบทวิ (binary logistic regression) ซึ่งใช้วิธี enter method ในการเลือกตัวแปรอิสระ (ลักษณะทางประชากรและสังคมและสถานะสุขภาพ) ที่มีความสัมพันธ์หรือมีนัยสำคัญทางสถิติเข้าสมการ[36]

4. การคำนวณระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก (high level of physical inactivity) เนื่องจากองค์การอนามัยโลกกำหนดว่า การมีกิจกรรมทางกายไม่เพียงพอ (physical insufficiency) คือ การมีกิจกรรมทางกายระดับปานกลางและหนัก รวมกันน้อยกว่า 600 MET-นาที/สัปดาห์ และการมีพฤติกรรมเนือยนิ่ง คือ การมีกิจกรรมที่มีค่าพลังงานเท่ากับ 1 MET เช่น การนั่งเฉยๆ[3,5] โดยการศึกษานี้ ได้สร้างตัวแปร “ระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก (high level of physical inactivity)" เพื่อแทนบุคคลที่ไม่มีกิจกรรมทางกายทั้งในระดับปานกลาง (4 MET) และหนัก (8 MET) ในทั้ง 3 กลุ่ม (กลุ่มการทำงาน กลุ่มการเดินทาง กลุ่มนันทนาการ) และมีพฤติกรรมเนือยนิ่ง (1 MET) ร่วมด้วย เพื่อแสดงให้เห็นถึงบุคคลที่มีความกระฉับกระเฉงน้อยตลอดทั้งวัน

5. การวิเคราะห์แจกแจงระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก กับข้อมูลลักษณะทางประชากรและสังคม และสถานะสุขภาพ โดยใช้ค่าสถิติพรรณนา การแจกแจงนับ ร้อยละ และสมการถดถอยโลจิสติกแบบทวิ (binary logistic regression) ซึ่งใช้วิธี enter method ในการเลือกตัวแปรอิสระ (ลักษณะทางประชากรและสังคม และสถานะสุขภาพ) ที่มีความสัมพันธ์หรือมีนัยสำคัญทางสถิติเข้าสมการ[36]

ผลการศึกษา

1. ข้อมูลลักษณะทางสังคมประชากรของกลุ่มตัวอย่าง

กลุ่มตัวอย่างที่ได้รับการวิเคราะห์จำนวน 108,416 คน คำนวณถ่วงน้ำหนักตามระเบียบวิธีทางสถิติเพื่อเป็นตัวแทนประชากรทั้งประเทศ คิดเป็น 52,382,909 คน อายุตั้งแต่ 18 ปีขึ้นไป เป็นเพศหญิง (ร้อยละ 51.8) และชาย (ร้อยละ 48.2) อาศัยอยู่ในและนอกเขตเทศบาลในสัดส่วนใกล้เคียงกัน โดยร้อยละ 50.4 ของกลุ่มตัวอย่างไม่จบการศึกษาหรือมีการศึกษาสูงสุดระดับประถมศึกษา ลักษณะทางสังคมประชากรอื่นดังแสดงในตารางที่ 1

2. ระดับกิจกรรมทางกายที่เพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก กับข้อมูลลักษณะทางประชากรและสังคม

ประชากรไทยอายุตั้งแต่ 18 ปีขึ้นไปร้อยละ 42.4 มีระดับกิจกรรมทางกายที่เพียงพอ เมื่อแจกแจงตามข้อมูลลักษณะทางประชากรและสังคมพบว่า เพศชายมีระดับกิจกรรมทางกายที่เพียงพอสูงถึงร้อยละ 49.2 ซึ่งสูงกว่าเพศหญิงที่มีเพียงร้อยละ 36.2 กลุ่มประชากรที่อายุมากตั้งแต่ 51 ปีขึ้นไป และไม่ได้ทำงาน เป็นกลุ่มที่มีระดับกิจกรรมทางกายที่เพียงพอน้อย (ร้อยละ 33.8 และ 28.8 ตามลำดับ) ในทางตรงกันข้ามผู้ที่ประกอบอาชีพด้านเกษตรกรรมและประมง และผู้ใช้แรงงานเป็นกลุ่มประชากรที่มีระดับกิจกรรมทางกายที่เพียงพอมากที่สุด (ร้อยละ 54.0 และ 56.5 ตามลำดับ)

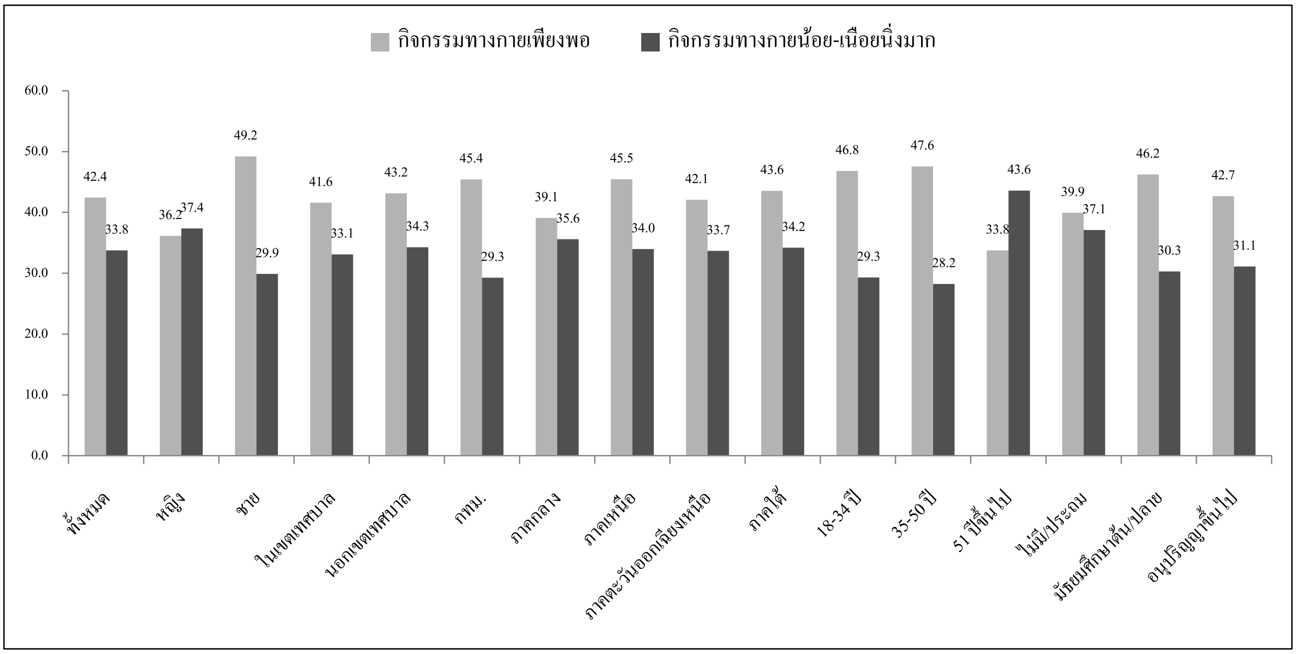
ส่วนระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ประชากรไทยที่มีอายุตั้งแต่ 18 ปีขึ้นไป ร้อยละ 33.8 จัดอยู่ในกลุ่มนี้ ซึ่งลักษณะของประชากรกลุ่มที่มีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ได้แก่ เพศหญิง (ร้อยละ 37.4) ประชากรที่มีอายุมากตั้งแต่ 51 ปีขึ้นไป (ร้อยละ 43.6) ผู้ที่จบการศึกษาระดับประถมหรือไม่มีการศึกษา (ร้อยละ 37.1) และคนที่ไม่ได้ทำงาน (ร้อยละ 46.1)

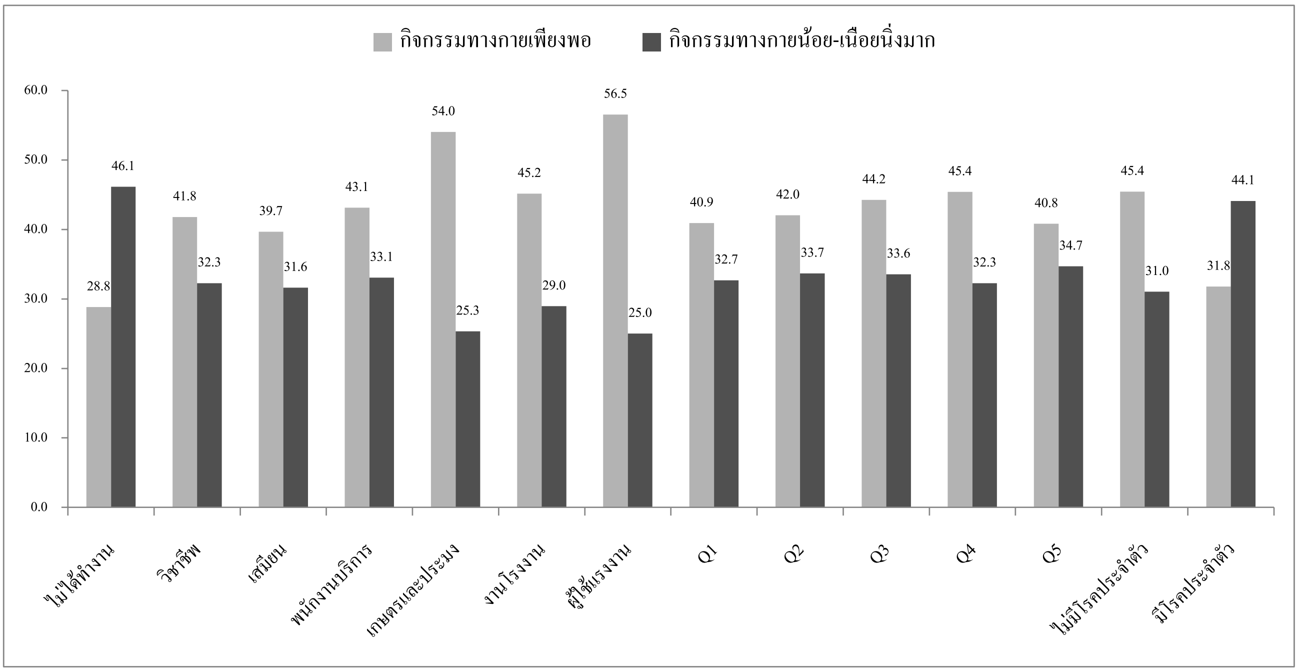
3. ระดับกิจกรรมทางกายที่เพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก กับสถานะสุขภาพของประชากร

ประชากรที่ไม่มีโรคประจำตัวมีระดับกิจกรรมทางกายที่เพียงพอ (ร้อยละ 45.4) ในสัดส่วนที่สูงกว่าประชากรที่มีโรคประจำตัว (ร้อยละ 31.8) เมื่อจำแนกสถานะสุขภาพของประชากร 5 ด้าน ได้แก่ การเคลื่อนไหว การดูแลตนเอง กิจกรรมที่ทำเป็นประจำ ความเจ็บป่วยหรือไม่สุขสบาย และความวิตกกังวลหรือซึมเศร้า โดยที่แต่ละด้านแบ่งตามระดับปัญหาสุขภาพเป็น 5 ระดับ ได้แก่ ไม่มีปัญหา มีปัญหาเล็กน้อย มีปัญหาปานกลาง มีปัญหามาก และไม่สามารถจะทำกิจกรรมด้านนั้นได้เลย พบว่าการมีปัญหาสุขภาพในระดับที่รุนแรงมากขึ้นในทุกด้านส่งผลให้ประชากรมีระดับกิจกรรมทางกายที่เพียงพอมีแนวโน้มลดลง เช่น ผู้ที่ประเมินสุขภาพตนเองด้านการเคลื่อนไหวในระดับที่รุนแรงมากที่สุด หรือเดินไม่ได้เลย จะมีระดับกิจกรรมทางกายที่เพียงพอน้อยที่สุด คือ ร้อยละ 15.2 ในขณะที่ผู้ที่มีปัญหาการเคลื่อนไหวมาก ปานกลาง เล็กน้อยและ

ตารางที่ 1 ลักษณะทางประชากรและสังคมของกลุ่มตัวอย่าง

ตัวแปร	ทั้งหมด	หญิง	ชาย
n (%)	52,382,909	51.8	48.2
เขตการปกครอง (%)			
นอกเขตเทศบาล	54.3	53.9	54.7
ในเขตเทศบาล	45.7	46.1	45.3
ภาค (%)			
กรุงเทพมหานคร	13.9	14.0	13.8
ภาคกลาง	29.6	29.4	29.7
ภาคเหนือ	17.2	17.2	17.1
ภาคตะวันออกเฉียงเหนือ	26.4	26.6	26.3
ภาคใต้	12.9	12.8	13.1
กลุ่มอายุ (%)			
18-34 ปี	31.5	30.4	32.8
35-50 ปี	33.5	33.2	33.8
51 ปีขึ้นไป	35.0	36.4	33.4
ระดับการศึกษาสูงสุด (%)			
ไม่มี/ประถมศึกษา	50.4	52.6	48.0
มัธยมศึกษาตอนต้น/ตอนปลาย	31.6	28.8	34.6
อนุปริญญาและสูงกว่า	18.0	18.6	17.4
อาชีพ (%)			
ไม่ได้ทำงาน	26.2	33.6	18.2
ผู้บัญญัติกฎหมาย ข้าราชการระดับอาวุโส ผู้จัดการ ผู้ประกอบวิชาชีพและช่างเทคนิคสาขาต่างๆ	8.6	8.1	9.1
เสมียน	3.3	4.5	1.9
พนักงานบริการ พนักงานขายในร้านค้าและตลาด	14.3	16.0	12.5
ผู้ปฏิบัติงานที่มีฝีมือด้านการเกษตรและประมง	24.9	21.8	28.2
ผู้ปฏิบัติงานในธุรกิจงานฝีมือ เครื่องจักรโรงงานและการประกอบ	15.0	8.2	22.4
ผู้ใช้แรงงานและอาชีพขั้นพื้นฐานต่างๆ	7.7	7.7	7.7
ดัชนีทรัพย์สินครัวเรือน (%)			
ควินไทล์ 1	21.1	23.4	19.7
ควินไทล์ 2	19.1	20.3	18.5
ควินไทล์ 3	22.1	21.1	22.7
ควินไทล์ 4	17.5	16.3	18.2
ควินไทล์ 5	20.2	18.9	20.9

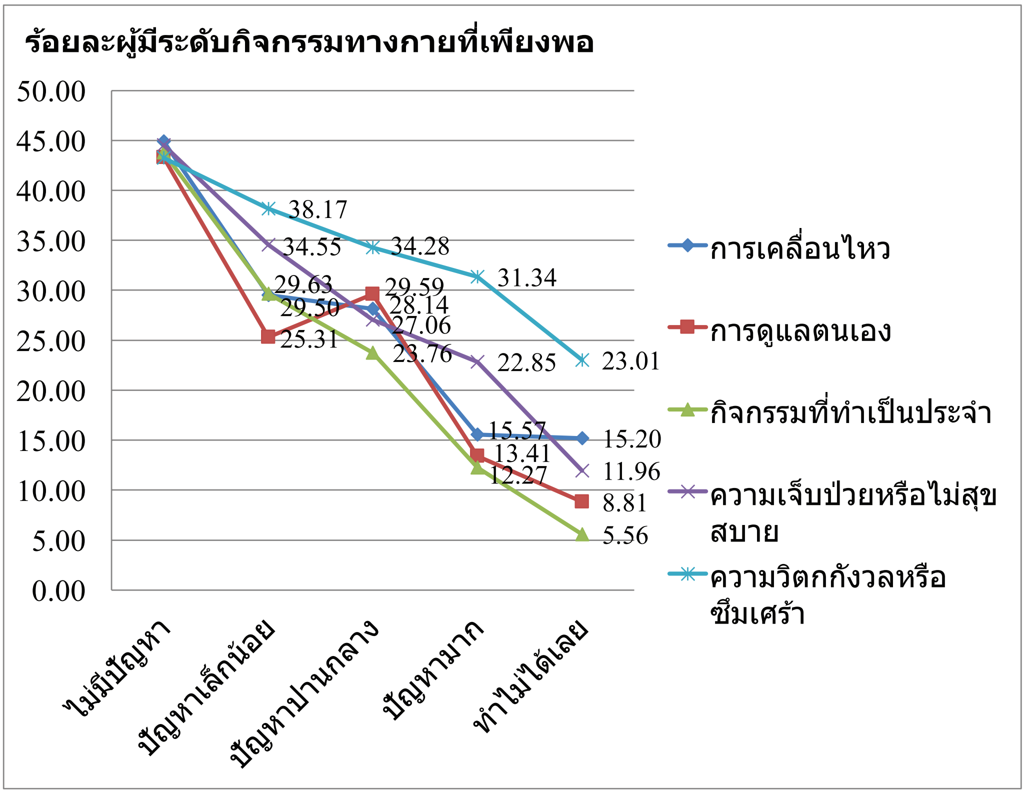




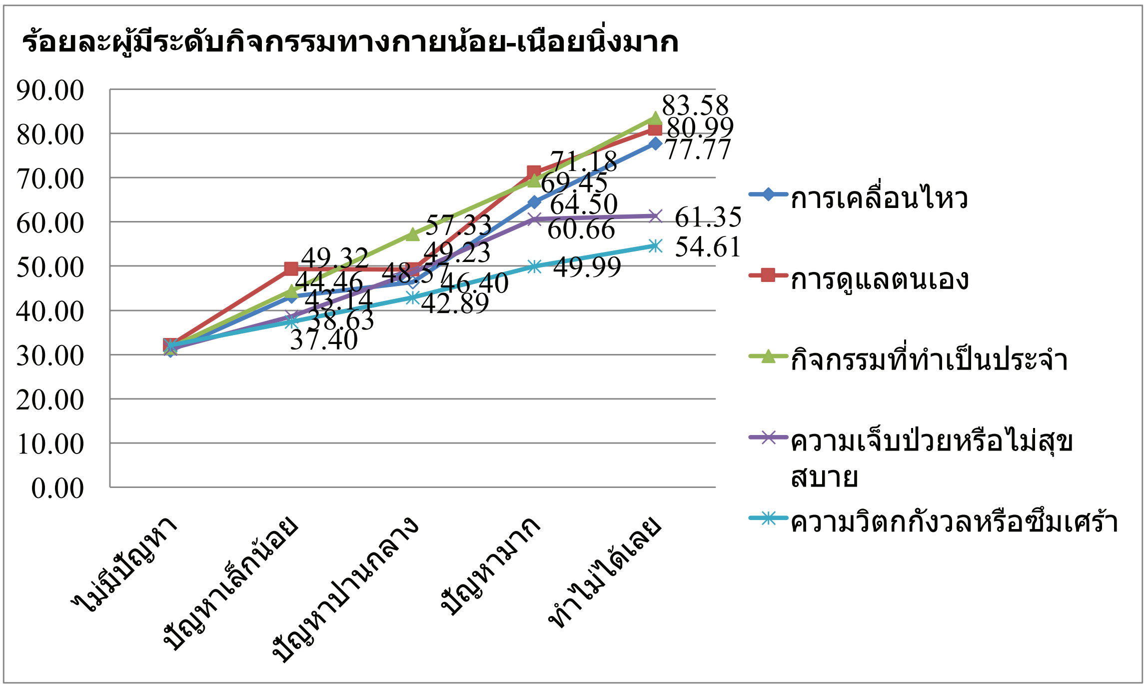
รูปที่ 1 ระดับกิจกรรมทางกายที่เพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก กับข้อมูลพื้นฐานส่วนบุคคล (ตัวเลขบนแท่ง เป็นร้อยละ)

ไม่มีปัญหา จะมีระดับกิจกรรมทางกายที่เพียงพอเพิ่มขึ้นตามลำดับ ได้แก่ ร้อยละ 15.6, 28.1, 29.5 และ 44.9

ในทางตรงกันข้าม ประชากรที่มีโรคประจำตัวเป็นกลุ่มที่มีกิจกรรมทางกายน้อย-เนือยนิ่งมาก (ร้อยละ 44.1) ในสัดส่วนที่สูงกว่าประชากรที่ไม่มีโรคประจำตัว (ร้อยละ 31.0) เมื่อจำแนกตามสถานะสุขภาพของประชากร 5 ด้าน พบว่าการมีปัญหาสุขภาพในระดับที่รุนแรงมากขึ้นในทุกด้าน สัมพันธ์กับการเพิ่มขึ้นของสัดส่วนประชากร



รูปที่ 2 กราฟการจำแนกผู้มีระดับกิจกรรมทางกายที่เพียงพอ กับสถานะสุขภาพของประชากร



รูปที่ 3 กราฟการจำแนกผู้มีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก กับสถานะสุขภาพของประชากร

ที่มีกิจกรรมทางกายน้อย-เนือยนิ่งมาก เช่น ผู้ที่ประเมินสุขภาพตนเองด้านกิจกรรมที่ทำเป็นประจำในระดับที่รุนแรงมากที่สุด หรือ ทำไม่ได้เลย จะมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก สูงที่สุด คือ ร้อยละ 83.6 ในขณะที่ผู้ที่มีปัญหาด้านกิจกรรมที่ทำเป็นประจำมาก ปานกลาง เล็กน้อย และไม่มีปัญหา จะมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ลดลงตามลำดับ ได้แก่ ร้อยละ 69.4, 57.3, 44.5 และ 31.6

4. การวิเคราะห์ปัจจัยพื้นฐานส่วนบุคคลที่ส่งผลต่อระดับกิจกรรมทางกายที่เพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ด้วยสมการถดถอยแบบทวิ

พบว่าการเป็นเพศชาย อายุน้อย ระดับการศึกษาสูง และการประกอบอาชีพ เพิ่มโอกาสการมีระดับกิจกรรมทางกายที่เพียงพอ โดยเฉพาะการทำงานด้านเกษตรกรรมและประมง การทำงานในโรงงาน และใช้แรงงาน เพิ่มโอกาสได้ถึง 3.54, 2.02 และ 3.99 เท่า ตามลำดับ เมื่อเทียบกับผู้ไม่ได้ทำงาน ในทางตรงกันข้าม การมีโรคประจำตัว และการมีปัญหาสุขภาพในระดับที่รุนแรงมากขึ้นจะลดโอกาสการมีระดับกิจกรรมทางกายที่เพียงพอ เช่น ผู้ที่ประเมินตนเองด้านกิจกรรมที่ทำเป็นประจำในระดับรุนแรงมากและมากที่สุด หรือทำไม่ได้เลย จะลดโอกาสการมีระดับกิจกรรมทางกายที่เพียงพอร้อยละ 46 และ 95 ตามลำดับ เมื่อเทียบกับผู้ที่ไม่มีปัญหาด้านนี้เลย อย่างไรก็ตาม การประเมินปัญหาสุขภาพด้านความวิตกกังวลหรือซึมเศร้า ระดับความรุนแรงของปัญหาที่มากขึ้นกลับส่งผลต่อการเพิ่มโอกาสการมีระดับกิจกรรมทางกายที่เพียงพออย่างมีนัยสำคัญ กล่าวคือ ผู้ที่มีความวิตกกังวลมาก ปานกลาง และเล็กน้อย มีโอกาสจะมีระดับกิจกรรมทางกายที่เพียงพอมากกว่าผู้ที่ไม่รู้สึกวิตกกังวลร้อยละ 87, 26 และ 15 ตามลำดับ

นอกจากนี้ การเป็นเพศชาย มีโอกาสที่จะมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก น้อยกว่าเพศหญิง ร้อยละ 16 การมีอาชีพช่วยลดโอกาสการมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก โดยเฉพาะอาชีพใช้แรงงานและทำงานด้านเกษตรกรรมและประมง มีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ต่ำกว่าผู้ไม่ได้ทำงาน ร้อยละ 66 เช่นเดียวกับระดับการศึกษาที่สูงขึ้น จะลดโอกาสการมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก (ร้อยละ 18 และ 26 ตามลำดับ) ในขณะที่การมีอายุที่มากขึ้น (51 ปีขึ้นไป) มีโอกาสการมีกิจกรรมทางกายน้อย-เนือยนิ่งมาก สูงกว่ากลุ่มอายุน้อย (18-34 ปี) ถึงร้อยละ 50

การมีปัญหาสุขภาพด้านการเคลื่อนไหวและกิจกรรมที่ทำเป็นประจำในระดับที่รุนแรงมากขึ้น เพิ่มโอกาสการมีกิจกรรมทางกายน้อย-เนือยนิ่งมาก เช่น ผู้ที่มีปัญหารุนแรงที่สุดด้านการเคลื่อนไหวและกิจกรรมที่ทำเป็นประจำ จะมีโอกาสมีกิจกรรมทางกายน้อย-เนือยนิ่งมาก สูงถึง 3.54 และ 3.63 เท่า ตามลำดับ เมื่อเทียบกับผู้ที่ไม่มีปัญหาด้านนั้นๆ ในทางตรงกันข้ามกับปัญหาสุขภาพด้านความวิตกกังวลหรือซึมเศร้า ที่ระดับความรุนแรงของปัญหาที่มากขึ้นส่งผลให้มีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ลดลง โดยผู้ที่มีความวิตกกังวลมาก ปานกลาง และเล็กน้อย มีโอกาสมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก น้อยกว่าผู้ที่ไม่รู้สึกวิตกกังวลร้อยละ 48, 30 และ 14 ตามลำดับ

วิจารณ์

1. ผลการศึกษา

ผลการศึกษาพบว่าประชากรไทยอายุตั้งแต่ 18 ปีขึ้นไป มีระดับกิจกรรมทางกายเพียงพอ ร้อยละ 42.4 เท่านั้น ซึ่งต่ำกว่าผลการศึกษาของประเทศไทยในช่วงที่ผ่านมา[6-11] และในระดับโลก[3] แม้ว่าจะใช้แบบสอบถาม GPAQ เหมือนกัน[9-11] แต่อาจด้วยกลุ่มประชากรตัวอย่างที่ใช้ในการศึกษาปัจจุบันครอบคลุมทั่วประเทศไทยมากกว่า และมีจำนวนมากกว่าถึง 1.4 แสนคน ในขณะที่การศึกษาที่ผ่านมา มีจำนวนกลุ่มประชากรตัวอย่าง

ตารางที่ 2 ปัจจัยพื้นฐานส่วนบุคคลที่ส่งผลต่อระดับกิจกรรมทางกายที่เพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก

ตัวแปร	กิจกรรมทางกายเพียงพอ			กิจกรรมทางกายน้อย-พฤติกรรมเนือยนิ่งมาก		
	%	Adjusted OR	95% CI	%	Adjusted OR	95% CI
เพศ						
หญิง	36.2	1.00		37.4	1.00	
ชาย	49.2	1.42*	(1.35-1.49)	29.9	0.84*	(0.79-0.88)
กลุ่มอายุ						
18-34 ปี	46.8	1.00		29.3	1.00	
35-50 ปี	45.6	0.89*	(0.82-0.98)	28.2	1.10	(1.00-1.20)
51 ปีขึ้นไป	33.8	0.69*	(0.63-0.76)	43.6	1.50*	(1.36-1.65)
เขตการปกครอง						
นอกเขตเทศบาล	43.2	1.00		34.3	1.00	
ในเขตเทศบาล	41.6	1.01	(0.96-1.06)	33.1	1.01	(0.96-1.06)
ภาค						
กรุงเทพมหานคร	45.4	1.00		29.3	1.00	
ภาคกลาง	39.1	0.67*	(0.59-0.76)	35.6	1.49*	(1.31-1.70)
ภาคเหนือ	45.5	0.99	(0.87-1.13)	34.0	1.13	(0.99-1.29)
ภาคตะวันออกเฉียงเหนือ	42.1	0.66*	(0.58-0.75)	33.7	1.28*	(1.12-1.46)
ภาคใต้	43.6	0.67*	(0.59-0.77)	34.2	1.48*	(1.29-1.69)
ระดับการศึกษาสูงสุด						
ไม่มี/ประถมศึกษา	39.9	1.00		37.1	1.00	
มัธยมศึกษาตอนต้น/ตอนปลาย	46.2	1.19*	(1.11-1.28)	30.3	0.82*	(0.77-088)
อนุปริญญาและสูงกว่า	42.7	1.28*	(1.16-1.41)	31.1	0.74*	(0.68-0.82)
อาชีพ						
ไม่ได้ทำงาน	28.8	1.00		46.1	1.00	
ผู้บัญญัติกฎหมาย ข้าราชการระดับอาวุโสผู้จัดการ ผู้ประกอบวิชาชีพและช่างเทคนิคสาขาต่างๆ	41.8	1.79*	(1.59-2.01)	32.3	0.60*	(0.53-0.67)
เสมียน	39.7	1.46*	(1.18-1.79)	31.6	0.62*	(0.51-0.77)
พนักงานบริการ พนักงานขายในร้านค้าและตลาด	43.1	1.86*	(1.71-2.02)	33.1	0.62*	(0.58-0.68)
ผู้ปฏิบัติงานที่มีฝีมือด้านการเกษตรและประมง	54.0	3.54*	(3.28-3.82)	25.3	0.34*	(0.32-0.37)
ผู้ปฏิบัติงานในธุรกิจงานฝีมือ เครื่องจักรโรงงานและการประกอบ	45.2	2.02*	(1.83-2.22)	28.9	0.54*	(0.49-0.59)
ผู้ใช้แรงงานและอาชีพขั้นพื้นฐานต่างๆ	56.5	3.99*	(3.58-4.45)	25.0	0.34*	(0.31-0.38)
ทรัพย์สินครัวเรือน						
ทรัพย์สินครัวเรือนควินไทล์ 1	40.9	1.00		32.7	1.00	
ทรัพย์สินครัวเรือนควินไทล์ 2	42.0	0.98	(0.91-1.06)	33.7	1.03	(0.96-1.12)
ทรัพย์สินครัวเรือนควินไทล์ 3	44.2	1.00	(0.93-1.08)	33.6	1.10*	(1.02-1.18)

ตารางที่ 2 ปัจจัยพื้นฐานส่วนบุคคลที่ส่งผลต่อระดับกิจกรรมทางกายที่เพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก

ตัวแปร	กิจกรรมทางกายเพียงพอ			กิจกรรมทางกายน้อย-พฤติกรรมเนือยนิ่งมาก		
	%	Adjusted OR	95% CI	%	Adjusted OR	95% CI
ทรัพย์สินครัวเรือนควินไทล์ 4	45.4	1.07	(0.99-1.17)	32.3	1.04	(0.96-1.13)
ทรัพย์สินครัวเรือนควินไทล์ 5	40.8	1.10*	(1.01-1.21)	34.7	1.02	(0.93-1.11)
การมีโรคเรื้อรัง/โรคประจำตัว						
ไม่มี	45.4	1.00		31.0	1.00	
มี	31.8	0.94*	(0.88-1.00)	44.1	0.98	(0.93-1.04)
การประเมินสุขภาพของตนเอง						
การเคลื่อนไหว						
ไม่มีปัญหา	44.9	1.00		30.9	1.00	
มีปัญหาเล็กน้อย	29.5	0.79*	(0.72-0.87)	43.1	1.10*	(1.01-1.20)
มีปัญหาปานกลาง	28.1	0.77*	(0.65-0.92)	46.4	1.21*	(1.04-1.41)
มีปัญหามาก	15.6	0.72	(0.49-1.07)	64.5	2.02*	(1.45-2.82)
เดินไม่ได้เลย	15.2	0.23	(0.05-1.07)	77.8	3.54*	(1.46-8.61)
การดูแลตนเอง						
ไม่มีปัญหา	43.3	1.00		32.1	1.00	
มีปัญหาเล็กน้อย	25.3	0.78*	(0.67-0.90)	49.3	1.26*	(1.11-1.43)
มีปัญหาปานกลาง	29.6	1.01	(0.76-1.35)	49.2	1.09	(0.85-1.40)
มีปัญหามาก	13.4	0.78	(0.38-1.57)	71.2	1.51	(0.87-2.64)
ทำไม่ได้เลย	8.8	2.95	(0.30-28.67)	81.0	0.95	(0.22-4.12)
กิจกรรมที่ทำเป็นประจำ						
ไม่มีปัญหา	43.8	1.00		31.6	1.00	
มีปัญหาเล็กน้อย	29.6	0.92	(0.81-1.04)	44.5	1.26*	(1.13-1.40)
มีปัญหาปานกลาง	23.8	0.90	(0.68-1.19)	57.3	1.59*	(1.25-2.02)
มีปัญหามาก	12.3	0.54*	(0.32-0.94)	69.5	1.85*	(1.22-2.82)
ทำไม่ได้เลย	5.6	0.05*	(0.01-0.50)	83.6	3.63*	(1.56-8.45)
ความเจ็บป่วยหรือไม่สุขสบาย						
ไม่มีอาการ	44.5	1.00		31.3	1.00	
มีอาการเล็กน้อย	34.5	1.02	(0.94-1.11)	38.6	0.88*	(0.82-0.95)
มีอาการปานกลาง	27.1	0.86	(0.71-1.03)	48.6	1.02	(0.86-1.20)
มีอาการมาก	22.8	0.94	(0.64-1.39)	60.7	1.09	(0.77-1.53)
มีอาการมากที่สุด	12.0	0.39	(0.08-1.79)	61.3	1.32	(0.43-4.08)
ความวิตกกังวลหรือซึมเศร้า						
ไม่รู้สึก	43.2	1.00		32.1	1.00	
รู้สึกเล็กน้อย	38.2	1.15*	(1.06-1.25)	37.4	0.86*	(0.80-0.93)
รู้สึกปานกลาง	34.3	1.26*	(1.03-1.53)	42.9	0.70*	(0.58-0.84)
รู้สึกอย่างมาก	31.3	1.87*	(1.28-2.74)	50.0	0.52*	(0.36-0.75)
รู้สึกอย่างมากที่สุด	23.0	2.81	(0.89-8.92)	54.6	0.66	(0.24-1.86)

หมายเหตุ: * = มีนัยสำคัญทางสถิติที่ความเชื่อมั่นมากกว่า 95% (p-value < 0.05)

ประมาณ 8,000-30,000 คน ทำให้ผลการศึกษาแตกต่างกันในการสำรวจระดับประเทศเหมือนกันและใช้แบบสอบถามเดียวกัน(7) แต่ด้วยเกณฑ์การคิดคำนวณระดับกิจกรรมทางกายเพียงพอที่ไม่เหมือนกัน ทำให้ผลการศึกษาแตกต่างกัน ทั้งนี้การศึกษานี้ ใช้หลักเกณฑ์การคำนวณจากองค์การอนามัยโลก โดยจากผลการศึกษานี้ชี้ให้เห็นว่า คนไทยมีระดับกิจกรรมทางกายเพียงครึ่งเดียวของเป้าหมายเท่านั้น เมื่อเทียบกับเป้าหมายการควบคุมและป้องกันโรคไม่ติดต่อเรื้อรังขององค์การสหประชาชาติ ที่คนไทยต้องมีระดับกิจกรรมทางกายเพียงพอร้อยละ 84 ภายในปี พ.ศ. 2568(12)

ทั้งนี้ เหตุผลหนึ่งอาจเนื่องมาจากโครงการรณรงค์และส่งเสริมกิจกรรมทางกายของหลายภาคส่วนที่ผ่านมา ล้วนมุ่งเน้นไปที่การมีกิจกรรมทางกายในกลุ่มนันทนาการเป็นหลัก(16-18) ทั้งๆ ที่หลายการศึกษาทั้งใน(16) และต่างประเทศ(19-21) ชี้ว่าพลังงานจากกิจกรรมทางกายในกลุ่มนันทนาการมีสัดส่วนน้อยที่สุดเมื่อเทียบกับกลุ่มกิจกรรมทางกายอื่น และมีแค่ประชากรบางกลุ่มเท่านั้นที่ใช้เวลาเพื่อการมีกิจกรรมทางกายในกลุ่มนันทนาการ อีกทั้งการเข้ามาของวิถีชีวิตที่เอื้อให้มีพฤติกรรมเนือยนิ่งมากขึ้น(11) ทั้งหมดนี้แสดงให้เห็นว่าประเทศไทยจำเป็นต้องพัฒนาและให้ความสำคัญกับนโยบายการส่งเสริมการมีกิจกรรมทางกายที่ครอบคลุมทุกกลุ่มกิจกรรม โดยเฉพาะการทำงานและการเดินทางที่อยู่ในวิถีชีวิตอยู่แล้ว และการลดพฤติกรรมเนือยนิ่งด้วย(15,16,21,22)

นอกจากนี้ การศึกษายังพบว่าคนไทยร้อยละ 33.8 มีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ซึ่งอาจเป็นอีกเหตุผลที่ทำให้ระดับกิจกรรมทางกายเพียงพอของคนไทยลดลงมาก เนื่องจากวิถีชีวิตที่เปลี่ยนแปลงไปและเทคโนโลยีที่ก้าวหน้าอย่างรวดเร็ว ทำให้ประชาชนมีพฤติกรรมเนือยนิ่งเพิ่มขึ้น ดังที่กล่าวข้างต้น ไม่ว่าจะเป็นการนั่งเล่นโทรศัพท์มือถือ การใช้คอมพิวเตอร์ในการทำงาน การนั่ง/นอนดูโทรทัศน์ การใช้รถยนต์ในการเดินทาง(15) ซึ่งตรงกับรายงานของสถาบันวิจัยประชากรและสังคม มหาวิทยาลัยมหิดล ที่พบว่าคนไทยใช้เวลาในกลุ่มพฤติกรรมเนือยนิ่งถึง 13.4 ชั่วโมงต่อวัน(11) ทำให้มีเวลาทำกิจกรรมทางกายลดลง

อีกทั้งผลการศึกษาในระยะหลัง พบว่าพฤติกรรมเนือยนิ่งเองยังเป็นหนึ่งในพฤติกรรมเสี่ยงที่ส่งผลเสียต่อสุขภาพ แม้ว่าบุคคลนั้นจะมีกิจกรรมทางกายเพียงพอตามระดับคำแนะนำขององค์การอนามัยโลก แต่หากยังมีพฤติกรรมเนือยนิ่งติดต่อกันเป็นเวลานานในแต่ละช่วงเวลาของวัน จะทำให้มีความเสี่ยงต่อการเจ็บป่วยด้วยโรคเรื้อรังด้วย อาทิ โรคหัวใจหลอดเลือด เบาหวาน มะเร็ง และภาวะเมตะบอลิคซินโดรม (metabolic syndrome)(33,34) และพบว่าในเด็กและเยาวชน การมีพฤติกรรมเนือยนิ่งยังส่งผลเสียต่อความแข็งแรงของกล้ามเนื้อ พฤติกรรมการเข้าสังคม และผลการเรียน(35)

ดังนั้น การส่งเสริมการมีกิจกรรมทางกาย และการลดพฤติกรรมเนือยนิ่ง เป็นมาตรการเร่งด่วนที่ต้องได้รับการผลักดันและขับเคลื่อนไปพร้อมกัน การเปลี่ยนหรือลดพฤติกรรมเนือยนิ่งให้เป็นกิจกรรมทางกายแทน ทั้งในระดับบุคคล โดยเฉพาะในเวลาทำงานหรือการเดินทาง ไม่ว่าจะเป็นการลุกยืน การเดินไปดื่มน้ำหรือเข้าห้องน้ำ หลังจากนั่งเก้าอี้ทำงานทุก 1 ชั่วโมง การยืนในช่วงเวลาพักงาน การเดินขึ้นลงบันไดแทนการใช้ลิฟต์ การเดินหรือปั่นจักรยานมาทำงานหรือในการเดินทาง การใช้ระบบขนส่งสาธารณะ เช่น รถไฟฟ้า รถไฟใต้ดิน การลงรถโดยสารประจำทางก่อนถึงจุดหมาย การจอดรถให้ไกลจากอาคารมากขึ้น พฤติกรรมเหล่านี้ล้วนช่วยส่งเสริมให้ประชาชนคนไทยได้มีกิจกรรมทางกายเพิ่มมากขึ้นในวิถีชีวิต และเป็นการลดพฤติกรรมเนือยนิ่งด้วย หรือในระดับนโยบายสำหรับประชาชนในภาพรวม ที่ภาครัฐและเอกชน ต้องส่งเสริมกิจกรรมทางกายและลดพฤติกรรมเนือยนิ่ง ด้วยการลงทุนด้านโครงสร้างพื้นฐานการขนส่งสาธารณะ สิ่งแวดล้อมสรรค์สร้างและพื้นที่สาธารณะ และการกำหนดนโยบายในสถานประกอบการหรือที่ทำงาน(15,16,21,22,34,35)

ผลการศึกษานี้ยังพบว่ากลุ่มที่มีระดับกิจกรรมทางกายเพียงพอสูง (ร้อยละ 49.2-56.5) และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากต่ำ (ร้อยละ 25.0-29.9) คือ ผู้ชาย ผู้ประกอบอาชีพด้านเกษตรกรรมและประมง ผู้ใช้แรงงาน และทำงานในโรงงาน เนื่องจากประชากรกลุ่มนี้มีอัตราการเผาผลาญพลังงานมากกว่ากลุ่มอื่น และมีลักษณะการทำงานที่ต้องการการเคลื่อนไหวร่างกายสูง ดังนั้น ประชากรในกลุ่มนี้ที่ยังมีกิจกรรมทางกายไม่เพียงพอจึงควรเป็นกลุ่มเป้าหมายในการส่งเสริมให้มีกิจกรรมทางกายเพิ่มขึ้น เนื่องจากเป็นกลุ่มประชากรที่มีความกระฉับกระเฉง และอยู่ในบริบทหรือสภาพแวดล้อมที่เอื้ออำนวยให้มีกิจกรรมทางกายเพิ่มได้

ในขณะที่ผู้สูงอายุ ผู้ไม่ได้ทำงาน และผู้ที่มีโรคประจำตัว เป็นกลุ่มที่มีระดับกิจกรรมทางกายเพียงพอต่ำ (ร้อยละ 28.8-33.8) และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากสูง (ร้อยละ 43.6-46.1) อาจเนื่องจากคนกลุ่มนี้มักจะมีกิจกรรมอยู่ในครัวเรือนซึ่งมีระดับความเข้มข้นของกิจกรรมทางกายที่ต่ำ และมีปัญหาสุขภาพซึ่งเป็นอุปสรรคต่อการมีกิจกรรมทางกายระดับหนัก[20,23-26] คนกลุ่มนี้จึงมีความเสี่ยงสูงต่อการเป็นโรคไม่ติดต่อเรื้อรัง[15,27] จึงควรให้ความสำคัญและสนับสนุนการหามาตรการส่งเสริมให้ประชากรกลุ่มนี้ลดพฤติกรรมเนือยนิ่ง และเปลี่ยนให้เป็นกิจกรรมทางกายระดับเบาหรือปานกลาง โดยเฉพาะในกลุ่มกิจกรรมครัวเรือน หรือส่งเสริมให้มีกิจกรรมทางกายเพิ่มเติมในการเดินทางและนันทนาการให้มากขึ้น และให้ตระหนักถึงผลเสียและความเสี่ยงต่อการเป็นโรคไม่ติดต่อเรื้อรังจากการมีพฤติกรรมเนือยนิ่ง อันจะช่วยลดความสูญเสียจากการเจ็บป่วยด้วยโรคไม่ติดต่อเรื้อรังทั้งในส่วนภาวะสุขภาพและต้นทุนทางเศรษฐกิจในการดูแลรักษาด้วย[4,12]

ในส่วนของสถานะสุขภาพ พบว่า ประชากรที่ไม่มีโรคประจำตัวและมีปัญหาสุขภาพน้อย มีระดับกิจกรรมทางกายเพียงพอสูงกว่า และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากต่ำกว่า เนื่องจากโรคประจำตัวและระดับปัญหาสุขภาพที่รุนแรง ส่งผลกระทบต่อกล้ามเนื้อร่างกายที่ใช้ในการเคลื่อนไหว จึงเป็นอุปสรรคต่อการมีกิจกรรมทางกาย[3,16,25,27]

ในทำนองเดียวกัน การวิเคราะห์ปัจจัยที่มีผลต่อการมีกิจกรรมทางกายเพียงพอ และการมีกิจกรรมทางกายน้อย-เนือยนิ่งมาก ด้วยสมการถดถอยแบบทวิ พบผลที่สอดคล้องกันและสามารถอธิบายได้ด้วยเหตุผลที่กล่าวมาข้างต้น ยกเว้นปัญหาสุขภาพด้านความวิตกกังวลหรือซึมเศร้า ที่ระดับความรุนแรงของปัญหาส่งผลให้มีระดับการมีกิจกรรมทางกายที่เพียงพอมากขึ้นและระดับการมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากลดลง และเมื่อพิจารณาปัจจัยที่ส่งผลต่อความเป็นไปได้ที่จะมีระดับกิจกรรมทางกายเพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ล้วนเป็นปัจจัยที่เปลี่ยนแปลงไม่ได้ (non-modifiable factors) เช่น เพศ อายุ ระดับการศึกษา และอาชีพ แต่การวิเคราะห์ดังกล่าวสามารถบอกกลุ่มประชากรที่เป็นกลุ่มเสี่ยงและระดับความเสี่ยงที่มากน้อยต่างกันได้ เช่น ยิ่งมีอายุมากขึ้นยิ่งมีความเป็นไปได้ที่จะมีระดับกิจกรรมทางกายเพียงพอน้อยลง หรือในการทำงาน อาชีพที่ไม่มีการเคลื่อนไหวมากมีแนวโน้มที่จะมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากสูง เป็นต้น

ข้อมูลกลุ่มประชากรที่มีระดับกิจกรรมทางกายเพียงพอสูง และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากต่ำ (ผู้ชาย ผู้ประกอบอาชีพด้านเกษตรกรรมและประมง ผู้ใช้แรงงาน และทำงานในโรงงาน) หรือกลุ่มที่มีระดับกิจกรรมทางกายเพียงพอต่ำ และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากสูง (ผู้สูงอายุ ผู้ไม่ได้ทำงาน และผู้ที่มีโรคประจำตัว) จะเป็นประโยชน์ในการใช้ประกอบการพิจารณาพัฒนานโยบายให้ตรงตามกลุ่มประชากรเป้าหมายต่อไป

2. ระเบียบวิธีวิจัยและข้อจำกัด

อคติจากความทรงจำ (recall bias) ของกลุ่มตัวอย่าง คือปัจจัยสำคัญที่อาจทำให้การรายงานระยะ

เวลาที่ใช้ในแต่ละกลุ่มกิจกรรมมีความคลาดเคลื่อน ส่งผลให้พลังงานที่ใช้มากหรือน้อยกว่าความเป็นจริง[11,16,31] อย่างไรก็ตาม การศึกษานี้พยายามลดความคลาดเคลื่อนโดยการกำหนดระยะเวลาที่เป็นไปได้ในการทำกิจกรรมทางกายในแต่ละวันในการคำนวณและวิเคราะห์ข้อมูล รวมถึงแบบสอบถามอาจมีการยกตัวอย่างแต่ละกิจกรรมไม่ครอบคลุมเพียงพอตาม GPAQ[5] ดังนั้นในการศึกษาครั้งต่อไปอาจพิจารณาปรับแบบสอบถามให้มีตัวอย่างชัดเจนขึ้น และวัดกิจกรรมทางกายด้วยเครื่องมือวัดการเคลื่อนไหวแบบติดตัว (accelerometer) ซึ่งปัจจุบันสามารถผลิตได้เองในประเทศไทย เพื่อให้ข้อมูลมีความแม่นยำมากขึ้น[32]

ข้อยุติ

จากการสำรวจอนามัยและสวัสดิการ ปี พ.ศ. 2558 พบประชากรไทยอายุตั้งแต่ 18 ปีขึ้นไป ร้อยละ 42.4 มีระดับกิจกรรมทางกายเพียงพอตามคำแนะนำขององค์การอนามัยโลก และร้อยละ 33.8 มีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก โดยกลุ่มที่มีระดับกิจกรรมทางกายเพียงพอสูง และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากต่ำ คือ ผู้ชาย ผู้ประกอบอาชีพด้านเกษตรกรรม ประมง ผู้ใช้แรงงาน และทำงานในโรงงาน และผู้ที่ไม่มีโรคประจำตัว ในทางตรงกันข้าม กลุ่มที่มีระดับกิจกรรมทางกายเพียงพอต่ำและมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากสูง คือ ผู้สูงอายุ ผู้ไม่ได้ทำงาน และผู้ที่มีโรคประจำตัว ซึ่งลักษณะทางสังคมประชากรดังกล่าวเป็นปัจจัยทำนายโอกาสการมีระดับกิจกรรมทางกายเพียงพอ และระดับกิจกรรมทางกายน้อย-เนือยนิ่งมาก ได้อีกด้วย

ข้อค้นพบจากการศึกษานี้น่าจะมีประโยชน์ในการนำไปใช้ประกอบการพิจารณาพัฒนานโยบายเพื่อลดพฤติกรรมเนือยนิ่งและเพิ่มกิจกรรมทางกายของคนไทย โดยเน้นการเพิ่มกิจกรรมทางกายในกลุ่มการทำงานและการเดินทาง และมุ่งเป้าไปที่การลดพฤติกรรมเนือยนิ่งในกลุ่มผู้สูงอายุ ผู้ไม่ได้ทำงาน และผู้ที่มีโรคประจำตัว ซึ่งมีระดับกิจกรรมทางกายเพียงพอต่ำ และมีระดับกิจกรรมทางกายน้อย-เนือยนิ่งมากสูง รวมถึงน่าจะมีประโยชน์ในการนำไปใช้ประกอบการพิจารณาแนวทางการพัฒนาการสำรวจกิจกรรมทางกายของคนไทยเพื่อให้ระบบฐานข้อมูลสมบูรณ์ สามารถนำไปใช้ประโยชน์ได้มากขึ้น

กิตติกรรมประกาศ

คณะผู้วิจัยขอขอบคุณ สำนักงานสถิติแห่งชาติที่ให้ข้อมูลการสำรวจอนามัยและสวัสดิการ พ.ศ. 2558 โดยให้ความอนุเคราะห์สำเนาข้อมูลดิบมาใช้ในการวิเคราะห์ครั้งนี้

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Correlates of physical activity and sedentary behaviour in the Thai population: a systematic review

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Abstract

Background: Given the importance of knowing the potential impediments and enablers for physical activity (PA) and sedentary behaviour (SB) in a specific population, the aim of this study was to systematically review and summarise evidence on individual, social, environmental, and policy correlates of PA and SB in the Thai population.

Methods: A systematic review of articles written in Thai and English was conducted. Studies that reported at least one correlate for PA and/or SB in a healthy Thai population were selected independently by two authors. Data on 21 variables were extracted. The methodological quality of the included studies was assessed using the Newcastle-Ottawa Scale.

Results: A total of 25,007 records were screened and 167 studies were included. The studies reported associations with PA for a total of 261 variables, mostly for adults and older adults. For most of the variables, evidence was available from a limited number of studies. Consistent evidence was found for individual-level and social correlates of PA in children/adolescents and adults and for individual-level correlates of PA in older adults. Self-efficacy and perceived barriers were consistently associated with PA in all age groups. Other consistently identified individual-level correlates in adults and older adults included self-rated general health, mental health, perceived benefits, and attitudes towards PA. Consistent evidence was also found for social correlates of PA in adults, including social support, interpersonal influences, parent/family influences, and information support. The influence of friendship/companionship was identified as a correlate of PA only in children/adolescents.
A limited number of studies examined SB correlates, especially in older adults. The studies reported associations with SB for a total of 41 variables. Consistent evidence of association with SB was only found for obesity in adults. Some evidence suggests that male adults engage more in SB than females.

Conclusions: More Thai studies are needed on (i) PA correlates, particularly among children/adolescents, and that focus on environment- and policy-related factors and (ii) SB correlates, particularly among older adults. Researchers are also encouraged to conduct longitudinal studies to provide evidence on prospective and causal relationships, and subject to feasibility, use device-based measures of PA and SB.

Keywords: Correlates, Physical activity, Sedentary behaviour, Systematic review, Thailand

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Background

Even though physical activity (PA) has been identified as the 'best buy' in public health [1] and national actions for the promotion of PA have been employed in many countries [2], population levels of PA are still declining [2–4]. In contrast, time spent performing sedentary behaviour (SB) is increasing [3, 4]. SB refers to any waking activity in a sitting, reclining, or lying position with low energy expenditure [5]. In the academic literature, SB has been conceptualised in two ways: (i) as a health risk factor 'independent' of PA [6]; and (ii) as a part of the time-use composition consisting of sleep, SB, and PA co-dependent time-use components [7]. In both conceptualisations, SB is deemed a potentially important factor for population health. Nevertheless, there seem to be barriers to the promotion of PA and reduction of SB, especially in low- and middle-income countries. These barriers include workforce shortages in the PA/SB sector (e.g. lack of PA promoters), weak networks of collaboration with other sectors (e.g. education, sports, and transportation), the lack of effective actions, and lack of knowledge about what approaches to PA promotion and SB reduction are feasible [2, 8]. These have been major challenges in Thailand, where efforts have been made to design and implement policy-level interventions.

To develop effective programs or interventions to increase PA and reduce SB, there is a need to understand correlates of these behaviours in specific populations. Public health experts advise that this need is urgent in low- and middle-income countries [2, 9]. Moreover, given substantial differences between geographical areas in social, cultural, environmental, and economic factors, it is important to explore PA and SB correlates in specific countries so that feasible interventions can be developed and designed based on local data [10]. Studies on PA correlates in low- and middle-income countries have recently started receiving more attention [2, 9–13]. Since 1987, and especially over the last two decades, PA has been the focus of a plethora of Thai epidemiological research, and the attention has most commonly been placed on its correlates [14].

In Thailand, the data from a 2015 population-representative survey on PA and SB showed that 21-25% of Thai children and adolescents (aged 6–17 years) achieved the recommended level of PA (i.e. 60 minutes a day) [15]. In addition, more than 78% of Thai children and adolescents engaged in two or more hours of SB [15]. Around 40% of Thai adults (aged 18 and above) met the World Health Organisation (WHO) recommendations for moderate-to-vigorous PA (MVPA) [16, 17]. Interestingly, 33.8% of Thai adults reported a high level of SB and no MVPA in the past week [16]. A better understanding of what makes some Thai population groups less active than others may help tackle the problem of insufficient PA.

Like other healthy behaviours, PA and SB are influenced by many factors [9, 18–22]. However, the focus to date has mostly been on individual-level correlates, such as sex, age, attitude, and self-rated general health [9, 11, 14, 20–22]. The social-ecological approach has been widely adopted to understand the interrelationships among multiple factors that contribute to PA and SB, including individual, social, environmental, and policy factors [9, 18–22]. The full spectrum of PA/SB correlates has been analysed in several reviews, mostly in high-income countries such as the United States, Australia, and Canada [9, 20–25]. Studies from low- and middle-income countries including Thailand have rarely been included [9, 20–25].

Given the importance of knowing which variables are associated with PA and SB in a specific population, the aim of this study was to systematically review and summarise the available evidence on individual, social, environmental, and policy correlates of PA and SB in Thai children, adolescents, adults, and older adults. We also aimed to identify the key gaps in the literature on PA and SB correlates in Thailand and provide recommendations for future research.

Methods

Search strategy

This systematic review was conducted by following the PRISMA guidelines [26]. The primary literature search was conducted from database inception to September 2016 using the following ten bibliographic databases: Academic Search Premier; CINAHL; Health Source: Nursing/Academic Edition; MasterFILE Premier; PsycINFO; PubMed/MEDLINE; Scopus; SPORTDiscus; Web of Science; and the Networked Digital Library of Theses and Dissertations (NDLTD). The secondary literature search was conducted by using three main sources, including: the Google and Google Scholar internet search engines (using search terms in both Thai and English); references of the studies that were selected in the primary search; and the websites/databases of Thai health-related organizations and institutes including the Division of Physical Activity, Ministry of Public Health; Thai Health Promotion Foundation; Health System Research Institute; Physical Activity Research Institute; Thai National Research Repository; Thai Thesis Database; Thai NCD Network; Kasetsart University Research; Chulalongkorn University Intellectual Repository; and Institute for Population and Social Research, Mahidol University.

Study selection and inclusion criteria

Two researchers (NL and KS) independently screened all references obtained from the search results, removed duplicates, and selected studies. The third author (ZP) resolved discrepancies about the study selections. The eligibility criteria included the following: Published peer-reviewed journal papers, theses, reports, and conference papers written in Thai or English were included, and reviews, commentaries, and editorials were excluded. Observational studies (cross-sectional, case-control, and prospective) that targeted healthy Thai people (as opposed to patients with a specific disease or health condition) of any ages were considered eligible for inclusion. To be included, the studies had to present the association of at least one variable with total PA (e.g. minutes per day or METs per week), MVPA, moderate PA (MPA), vigorous PA (VPA), meeting/not meeting PA guidelines (e.g. meeting the PA recommendation of 60 minutes of MVPA per day), domain-specific PA (e.g. recreation, transportation), and exercise participation. For SB measures, total SB or sitting time or frequency and/or duration in one or more of sedentary activities including television (TV) viewing, screen time, and computer/internet use were included. Both self-reported and devise-based measurements qualified for inclusion. Longitudinal studies that analysed PA or SB as predictors of an outcome variable, were not considered eligible for inclusion.

Data extraction

The following data were extracted from the selected studies: (a) general bibliographical information, such as publication type and language; (b) research methods used, including sampling techniques; (c) characteristics of the study population such as sex, age, and region; (d) description of PA/SB measure, including the PA type as a dependent variable and validity information; (e) specific correlate(s) with an assigned, categorized domain such as socio-demographic, psychological, and social factors; and (f) the type of statistical analysis used in the included studies. Data were extracted separately for three age groups: children and adolescents (<18 years old); adults (between 18 and 59 years old); and older adults (>60 years old). The full extraction tables are provided in the Additional file 1.

Data coding and pooling

To pool the results of individual studies, we used the procedure proposed by Sallis et al. [24]. The pooled associations between potential correlates and PA and SB were classified as: a) mostly positive associations (denoted by '+'); b) mostly negative associations (denoted by '-'); or c) mostly non-significant, indeterminate, or inconsistent associations (denoted by '?'). The codes were determined based on the percentage of significantly positive, significantly negative, and non-significant associations, according to the rules presented in Table 1 [24]. The classification system was slightly adapted from the original categorisation used by Sallis et al. [24], to better reflect the implication of non-significant relationships. The results from the most adjusted analysis reported in a paper were used for the classification. Letters 'M' and 'F' were used to indicate findings for male and female participants when results were reported separately for sexes.

Table 1 Rules applied to classify correlates of physical activity

Percentage of studies (%)[a]	Code describing the association between a correlate and PA or SB[b]	Meaning of the code
0 - 59	?	Mostly non-significant, indeterminate, or inconsistent associations
60 - 100	+ or –	Mostly positive (+), or negative (–) associations

[a]Percentage of studies showing positive, negative, or non-significant association
[b]When four or more studies showed positive or negative association, the summary results were coded as ++, and --, respectively. The code "??" denoted a frequently studied correlate whose association with PA or SB was largely inconsistent across the studies

A synthesis of the findings of this review was structured by applying the social-ecological model of PA/SB, where all correlates were categorised into key components of the model including individual (e.g. socio-demographic, biological), social (e.g. interpersonal, cultural), physical environment (e.g. facilities, neighbourhood), and policy (e.g. education and workplace policies) factors. The pooled results are presented separately for children and adolescents (6-17 years), adults (18-59 years), and older adults (60 years and over). We used this threshold for the 'older adults' group, because, according to the Thai Labour Protection Act, the retirement age applies to adults aged 60 years and more [27].

Risk of bias

The methodological quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) [28]. NOS was designed to evaluate the quality of observational studies for several purposes, such as to include/exclude studies for meta-analysis, weight studies, and address areas that need methodological improvements [29]. The three aspects of studies that were assessed using the NOS tool included the selection of study groups (4 items, maximum 5 points), adjustments for potential confounders (1 item, maximum 2 points), and ascertainment of exposure and outcomes (2 items, maximum 3 points) [28, 29]. The overall score was calculated as the sum of points across the three categories. The overall scores were classified into three groups: low (<5 points), moderate (5-7 points), and high (>7 points) study quality [30].

Results

Characteristics of the included studies

The search and study selection processes are illustrated in Fig. 1. A total of 25,007 records were identified. Of these, 167 papers met the eligibility criteria and were included in the present review. Most studies focused on

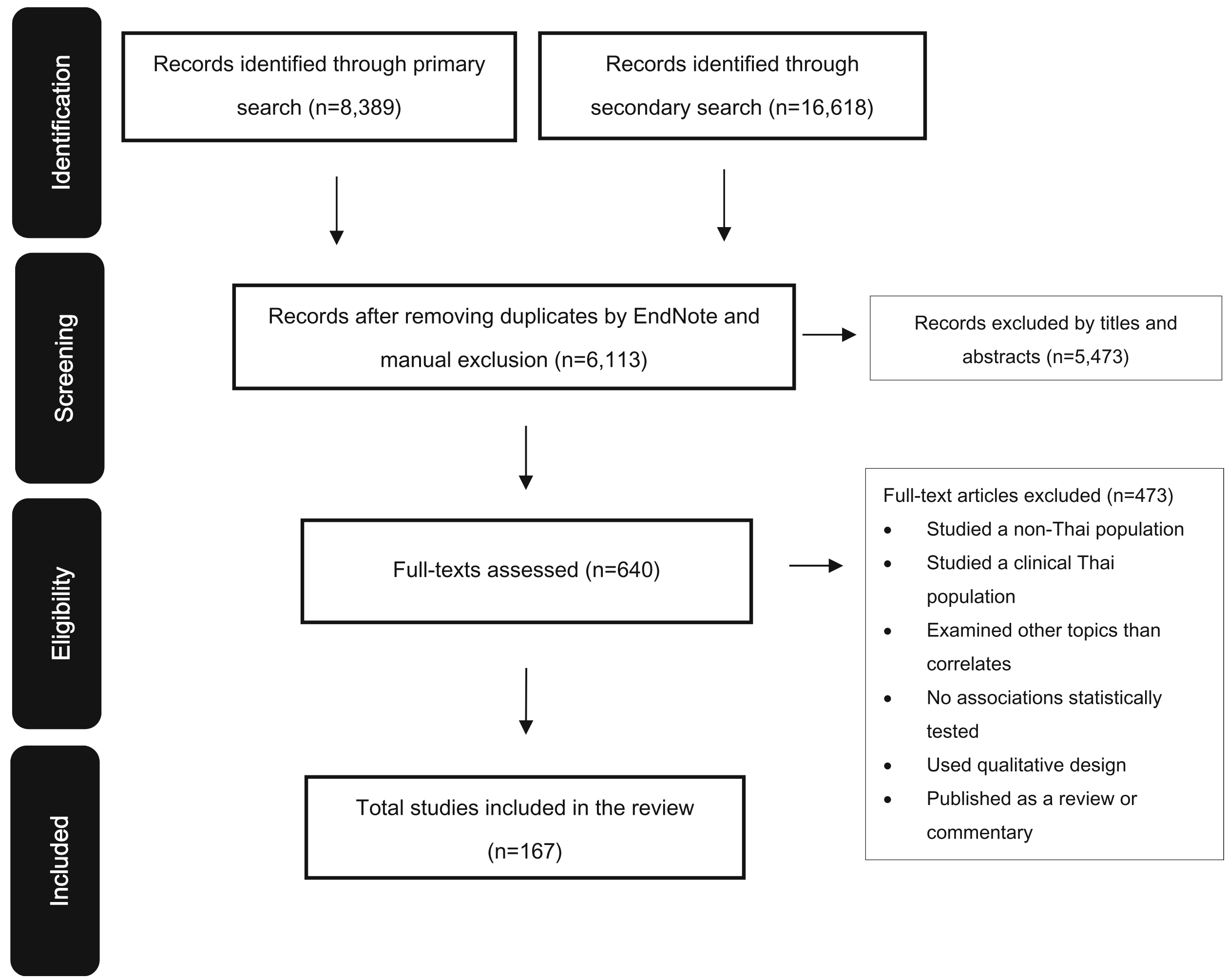

Fig. 1 Flow diagram of study selection process

PA only (76%; n = 127), 15 studies (9%) examined SB correlates only, and 25 studies (15%) examined correlates of both PA and SB. The included articles were published between 1993 and 2016. All studies used a cross-sectional design. The average sample size cited in the studies was 3,317 and ranged from 27 to 87,134. Two studies included only male participants (1.2%), 17 studies included only female participants (10.2%), and the remainder included both sexes (88.6%; n = 148). Half of the studies were conducted among adults (50.3%; n = 100), followed by older adults (28.6%; n = 57) and children/adolescents (21.1%; n = 42). Of these, twenty-nine studied on adults/older adults and three on adolescents/adults. Most of the included publications were articles published in peer-reviewed journals (69.5%; n = 116), more than a quarter were doctoral and master's theses (26.9%; n = 45), and the remaining publications were reports (2.4%; n = 4) and conference papers (1.2%; n = 2).

Nearly all studies were conducted using self-report instruments to measure PA (97.6%; n = 163). Three studies used accelerometers (1.8%) and one study used pedometers (0.6%). Sixty-three percent of the studies used previously validated PA measures (n = 96). More than half of the studies measured exercise participation (54.9%; n = 89), followed by MVPA (19.1%; n = 31) and total PA (13.6%; n = 22). Domain-specific PA was assessed in 6.8% of the studies (n = 11), which mainly included recreation and household PA. The remaining studies assessed VPA (3.1%; n = 5) and MPA (2.5%; n = 4). Presenting correlates of each PA type separately are available in the Additional file 2: Tables S1-S22.

SB was assessed using self-report instruments in all but one study. Most instruments used to measure SB had been previously validated (62.5%; n = 25). Watching television was the main SB independently investigated in several studies (30.6%; n = 15), followed by total SB time (20.4%; n = 10). Other individual sedentary activities included computer and internet use that were examined in 16.3% (n = 8) and 10.2% (n = 5) of the studies respectively. Screen time, which refers to TV viewing and computer use combined, was assessed in 12.2% of the studies (n = 6). The remainder observed the total duration of sitting during leisure time (6.1%; n = 3) and at work (4.1%; n = 2).

Methodological quality

The median overall score of the included studies on the NOS was 6 ('moderate quality'). Twenty-three studies were categorised as 'high quality', 34 were considered 'low quality', while the remainder were of moderate quality (n = 110). Among the high-quality studies, seven studies dealt with children and adolescents, seven focused only on adults, two only on older adults, and seven on both adults and older adults. It was, therefore, not considered appropriate to perform a sensitivity analysis using only findings from high-quality studies, due to the fact that too few of these studies were available. The results of the quality assessment for all the included studies can be found in the Additional file 3.

Physical activity correlates

The included studies reported associations with PA for a total of 261 variables [31–181]. Almost half of the variables were significantly associated with PA (47.5%; n = 124). Multiple factors were assessed, including individual, social, physical, and policy environment variables. The most frequently studied factors were those at the individual level (81.6%; n = 213). The statistically significant correlates most often included psychological factors, followed by biological, demographic, and health behavioural and lifestyle factors (Fig. 2).

Correlates of children's and adolescents' physical activity

A total of 52 potential PA correlates were studied in Thai children and adolescents (Table 2). Consistent evidence of association with higher PA was found for the following individual-level factors: younger age, being a male, higher self-efficacy, and lower perceived barriers. Consistent evidence of association with higher PA was found for the social factor of greater friendship/companionship influences. No consistent evidence was found for environmental and policy correlates of PA.

Some evidence supported associations between higher PA and the following individual-level factors: lower household income, going to mixed-gender schools (compared with single-gender schools), higher self-rated general health, greater enjoyment of PA/exercise, more past PA/exercise experience, higher resilience, higher perceived physical competence, greater knowledge of PA/exercise, not having asthma and hypertension, lower body dissatisfaction, lower duration of TV viewing, and lower grade point average. Some evidence supported associations between higher PA and the following social factors: greater parent/family influences, more involvement with friends, ease in making friends, better social supports, greater teacher influences, greater general interpersonal influences, and better information support. Some evidence supported associations between higher PA and the following environmental factors: better environmental supports,

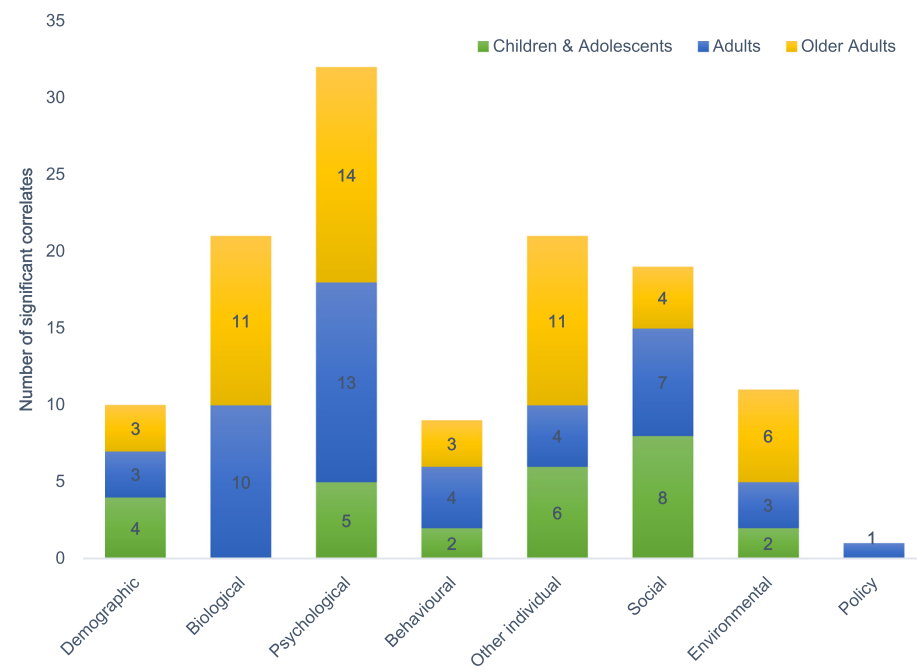

Fig. 2 The number of significant correlates of physical activity across different categories

Table 2 Summary of evidence on physical activity (PA) correlates in Thai children and adolescents (6 – 17 years old)

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age	97, 135 (M, F), 183		158 (M, F)	--
– Sex (+ denotes males are more active, - denotes females are more active)		51, 55, 97, 111, 118, 122, 126, 135, 158, 167, 178, 183	169, 189	++
– Household income	96, 178			-
– School type (+ denotes more PA in mixed-gender schools, - denotes more PA in single-gender schools)		55		+
– School grade	80		51, 118, 167, 189	??
– Parents' occupation			189	?
– Municipality (+ denotes more PA in an urban place of residence, - denotes more PA in a rural place of residence)		169	135 (M, F), 64	?
– Household location within Bangkok			178	?
Biological factors				
– Body weight			135 (M, F)	?
– Body mass index (BMI)	97, 178		33, 51, 135 (M, F), 158	??
– Parents' BMI			178	?
– Underweight			110	?
– Overweight	110, 157	111 (F)	52, 111 (M), 125 (F)	?
– Obesity	110, 130 (M), 157		125 (F), 130 (F), 169	?
– Body fat (%)		135 (M)	135 (F)	?
– Height	135 (M, F)		77 (M, F)	?
– Low-density lipoprotein cholesterol (LDL-C) level			158	?
– Systolic blood pressure			158	?
– Diastolic blood pressure			158	?
– Dietary fat intake			158	?
Physical health				
– Asthma	157			-
– Hypertension	157			-
General health				
– Self-rated general health		121 (M, F)		+
– Child's health status as perceived by parents			45	?
Psychological factors				
– Self-efficacy		45, 51, 80, 123	167	++
– Perceived benefits of PA/exercise		51, 80	38 (M, F), 167	?
– Perceived barriers for PA/exercise	38 (F), 51, 80, 123		38 (M), 167	--
– Attitudes towards PA/exercise		178	167	?
– Self-esteem			167	?
– Cues to action			38 (M, F)	?
– Being bullied	129 (M)		129 (F)	?
– Expected outcomes of PA/exercise			167	?
– Body dissatisfaction	55			-

Table 2 Summary of evidence on physical activity (PA) correlates in Thai children and adolescents (6 – 17 years old) *(Continued)*

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Enjoyment of PA/exercise		80, 183	178	+
– Resilience		118		+
Physical skills, abilities, and fitness				
– Perceived physical competence		183		+
Health behavioural and lifestyle factors				
– Past PA/exercise experience		51, 80	167	+
– TV viewing	178			-
Knowledge				
– Knowledge about PA/exercise		167		+
– Parents' knowledge about school-aged children's PA			45	?
Academic/school performance				
– Grade point average	157			-
Social environment				
Social and cultural factors				
– Social support		123, 178	167	+
– Parent/family influences		80, 183	178	+
– Friendship/companionship influences		80, 122 (M, F), 183		++
– Involvement with friends		122 (M, F)		+
– Ease in making friends		122 (M, F)		+
– Teacher influences		80		+
– General interpersonal influences		51		+
– Information support (e.g. social media)		167		+
Physical environment				
Environmental factors				
– Environmental support (e.g. situational influences)		51, 80, 178		+
– Supportive physical environment (e.g. facilities, supplies)		178	167	?
– Supportive neighbourhood environment		178		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

and better neighbourhood environment. No evidence was found for policy correlates of PA.

The associations between PA and school grade and body mass index (BMI) were mostly non-significant or largely inconsistent.

Correlates of adults' physical activity

In total, 120 potential correlates of PA were studied in Thai adults (Table 3). Consistent evidence of association with higher PA was found for the following individual-level factors: higher self-rated general health, better mental health, positive attitudes towards PA/exercise, higher self-efficacy, higher perceived benefits of PA/exercise, lower perceived barriers for PA/exercise, and more spare time. Consistent evidence of association with higher PA was found for the following social factors: better social support, greater general interpersonal influences, greater parent/family influences, and better information support. No consistent evidence was found for environmental and policy correlates of PA.

Some evidence supported associations between higher PA and the following individual-level factors: being underweight, higher HDL-cholesterol level, higher VO_2Max, lower triglycerides (TG) level, lower total cholesterol: HDL-C ratio, lower risk of having high TG, lower resting heart rate, lower haematocrit level, lower age-related macular degeneration, more years of working experience, having a 'dream job', ever attended a workshop on exercise, higher dietary calcium intake, higher sunlight exposure, having osteoporosis, greater overall health belief,

Table 3 Summary of evidence on physical activity (PA) correlates in Thai adults (18 – 59 years old)

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factor				
– Age		37, 58, 59, 107, 124, 140, 172	58, 72, 81, 112, 116, 117, 155, 176, 190, 197	??
– Sex (+ denotes males are more active, - denotes females are more active)	50, 100, 155, 196	31, 83, 87, 100, 107, 113, 116, 117, 131, 132, 136, 150, 159, 165, 180, 181, 184, 186, 190, 193, 195	36, 44, 58, 59, 72, 92, 95, 112, 124, 140, 172, 176, 194, 197	??
– Municipality (+ denotes more PA in an urban place of residence, - denotes more PA in a rural place of residence)	58		58	?
– Marital status (+ denotes singles are more active)		155	58, 59, 72, 81, 101, 112, 117, 172, 190, 197	??
– Education level	58, 116, 117, 181	59, 155, 190	58, 72, 101, 112, 172, 197	??
– University year	165	137, 186	36, 95, 179, 193, 195	??
– Faculty*		44, 87, 165, 194, 195, 196	92, 95, 159, 179, 186	??
– Household income	117	58, 92	58, 59, 72, 101, 172, 179, 181, 190, 195, 197	??
– Occupation (+ denotes unemployed are more active)		155, 190	58, 59, 101, 117	??
– Region (+ denotes Central including Bangkok residents are more active, - denotes residents of other provinces are more active)	134	155	172	?
– Early-life (0-5) urban exposure			35	?
– Number of family members			101	?
– Student residency (+ denotes residents of university dorms are more active, - denotes students living in other accommodation types are more active)		195	95, 181	?
– Hometown (urban/rural)			92	?
– Campus/working location*		163, 197	44, 112, 159, 194	??
– Having a dependant			81	?
– Years of working experience		172		+
– Working position			112, 172, 197	?
– Working type			197	?
– Duration of health club membership			117	?
– Having a 'dream job'		92		+
– Extra job (+ denotes yes, - denotes no)			112	?
– Ever attended a workshop on exercise (+ denotes yes, - denotes no)		124		+
Biological factors				
– Body mass index (BMI)	179	180	58, 109, 181, 197	??
– Underweight		131 (F), 150	131 (M)	+
– Overweight	150		65 (M, F), 114, 131 (M, F), 146 (M, F)	??

Table 3 Summary of evidence on physical activity (PA) correlates in Thai adults (18 – 59 years old) *(Continued)*

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Obesity	46 (M, F), 47 (M, F), 86, 114, 150		65 (M, F), 128, 131 (M, F)	??
– Waist circumference			197	?
– Body fat (%)			109	?
– Bone mineral density (BMD)		134, 138, 160 (M, F)	74, 90, 145	?
– Calcaneal stiffness index		160 (M, F)	160 (M, F)	?
– Skeletal muscle mass percent			143	?
– Dietary calcium intake		138		+
– Adequate serum vitamin D levels			143	?
– Sunlight exposure		138		+
– Total cholesterol (TCH) level			60 (M, F), 107	?
– Triglycerides (TG) level	60 (M, F), 107			-
– HDL-cholesterol level		60 (M, F), 107		+
– LDL-cholesterol level			107	?
– Total cholesterol: HDL-C ratio	60 (M, F)			-
– High TCH			60 (M, F)	?
– High TG	60 (M, F)			-
– Low HDL-C			60 (M, F)	?
– High TCH: HDL-C ratio			60 (M, F)	?
– Resting heart rate	107, 166 (M, F)			-
– Mean heart rate			166 (M, F)	?
– Predicted maximum heart rate (%)			166 (M, F)	?
– Systolic blood pressure			107, 166 (M, F)	?
– Diastolic blood pressure			107, 166 (M, F)	?
– Fasting plasma glucose			107	?
– VO_2max		166 (M, F)		+
– FEV1 (Abnormal lung function)			166 (M, F)	?
– FVC (Pulmonary function test)			166 (M, F)	?
– FEV1/FVC (%)			166 (M, F)	?
– Hematocrit level	73			-
– Hypercholesterolemia			103 (M, F)	?
Physical health				
– History of sickness/Underlying illness/Co-morbid diseases (+ denotes yes, - denotes no)			59, 101, 112, 181, 195, 197	??
– Hypertension			69	?
– Metabolic syndrome			136 (M, F)	?
– Osteoporosis		138		+
– Musculoskeletal symptoms	63, 144		85, 89, 133	?
– Relative appendicular skeletal muscle mass (RASM)		105 (F)	105 (M)	?
– Dysmenorrhea			57 (F)	?
– Age-related macular degeneration (AMD)	88			-

Table 3 Summary of evidence on physical activity (PA) correlates in Thai adults (18 – 59 years old) *(Continued)*

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
General health				
– Self-rated general health		87, 94, 175, 194, 197	159	++
Psychological factors				
– Mental health		32, 94, 175, 190		++
– Attitudes towards PA/exercise		49, 50 (M, F), 117, 154, 165, 186, 188, 190, 197	44, 70, 82, 112	++
– Overall health belief		170		+
– Self-efficacy		81, 83, 87, 140, 159, 172, 187, 194	72, 101, 137	++
– Perceived benefits of PA/exercise		50 (M, F), 83, 87, 101, 137, 172, 175, 194	59, 72, 159, 170, 187	++
– Perceived barriers for PA/exercise	72, 83, 87, 159, 170, 172, 176, 194		62, 101, 187	--
– Outcome expectancies		81, 140		+
– Intention to PA/exercise		140, 179		+
– Enjoyment of PA/exercise		59		+
– Perceived exercise-related effect	140		72, 170	?
– Career satisfaction		182		+
– Motivation for PA/exercise		83	76, 195	?
– External regulation			76	?
– Extrinsic motivation	76			-
– Intrinsic motivation		76		+
– Commitment to PA/exercise			151	?
– Stress level	179			-
– Sense of coherence			108	?
– Identity achievement			108	?
– Score on memory and intelligence tests			32	?
Physical skills, abilities, and fitness				
– Physical and functional fitness (e.g. walking distance, leg strength)		94, 166 (M, F)		+
Health behavioural and lifestyle factors				
– Smoking			78 (M, F), 153	?
– Alcohol consumption		177 (M)	177 (F)	?
– Healthy dietary habits		119		+
– Past PA/exercise experience		72		+
– Being a university athlete			137, 165	?
– Availability and/or engagement in enjoyable sports		115, 137		+
– Loving watching sports			115	?
– Having a favourite athlete			115	?
– Sedentary time	58		127	?
– Spare time		49, 59, 82, 115		++
– Monosodium glutamate (MSG) intake			71	?
Knowledge				

Table 3 Summary of evidence on physical activity (PA) correlates in Thai adults (18 – 59 years old) *(Continued)*

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Knowledge about PA/exercise	154	44, 50 (M, F), 59, 101, 117, 188, 194	49, 82, 87, 112, 159, 165, 195, 197	??
Academic/school performance				
– Grade point average			179	?
Social environment				
Social and cultural factors				
– Social support		50 (M, F), 87, 154, 159, 165, 180, 194, 197	101	++
– Cultural support		180		+
– General interpersonal influences	151	49, 82, 154, 187, 197	117	++
– Parent/family influences		81, 83, 137, 172	72, 117	++
– Family members' involvement in PA/exercise		137		+
– Friendship/companionship influences		81		+
– Friends' involvement in PA/exercise			115	?
– Information support (e.g. from media)		49, 154, 159, 194, 197	82	++
– Religion (+ denotes Buddhists are more active, - denotes Muslims are more active)		184	95	?
Physical environment				
Environmental factors				
– Environmental support (e.g. situational influences)		137	72, 151, 195	?
– Supportive physical environment (e.g. facilities, supplies)		81, 82, 87, 154	49, 101, 197	?
– Supportive neighbourhood environment			81	?
– Urban environment	35, 100 (M, F)			-
– Distance to work			58	?
– Distance to the nearest shopping place	58			-
– Distance to the nearest recreation facility			58	?
– Distance to the nearest religious establishment			58	?
– Convenience of travel			115	?
– Month of the year (+ denotes higher PA in later months of a calendar year)		109		+
Policy				
Policy attribute				
– Supportive education policies		82, 154, 165	49	+
– Supportive workplace policies			197	?

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female, Faculty* and Campus/working location* variables - due to a number of categories of these variables, we used only + (to denote any significant association of specific faculties or campuses/working locations) and ? (to denote a non-significant association) codes.

higher career satisfaction, higher intrinsic motivation, healthier dietary habits, past PA/exercise experience, more enjoyment of PA/exercise, higher outcome expectancies, greater intention to take part in PA/exercise, better physical and functional fitness, engaging in enjoyable sports, lower extrinsic motivation, and lower stress level. Some evidence supported associations between higher PA and the following social factors: better cultural support, family members' involvement in PA/exercise, and greater friendship/companionship influences. Some evidence of association with higher PA was found for the following environmental factors: less exposure to urban environment, later months of a calendar year (compared with the other months), and shorter distance to shopping place. Some evidence supported association between higher PA and the policy factor of better supportive education policies.

The associations between PA and age, sex, marital status, education level, university year, faculty, household income, occupation, campus/working location, BMI, being overweight, obesity, history of sickness, and knowledge of PA/exercise were mostly non-significant or largely inconsistent.

Correlates of older adults' physical activity

A total of 89 potential correlates of PA were studied in Thai older adults (Table 4). Consistent evidence of association with higher PA was found for the following individual-level factors: higher self-rated general health, better mental health, positive attitudes towards PA/exercise, higher self-efficacy, higher perceived benefits of PA/exercise, lower perceived barriers for PA/exercise, higher outcome expectancies, greater knowledge of PA/exercise, and better physical and functional fitness. No consistent evidence was found for social, environmental, and policy correlates of PA.

Some evidence of association with higher PA was found for the following individual-level factors: being a senior-citizen club member, being a Buddhist (when compared with being a Muslim), not being obese, lower triglyceride (TG), lower total cholesterol: HDL-C ratio, less likely to have high TG, lower resting heart rate, higher bone mineral density (BMD), higher HDL-cholesterol, higher VO_2max, better health-related quality of life, ever attended a workshop on exercise, higher dietary calcium intake, higher sunlight exposure, better saliva flow rate, less daily duty, lower hematocrit level, less likely to have abnormal symptoms, not having osteoporosis, not having age-related macular degeneration, not having periodontal disease, not perceiving exercise-related effect, lower score on Timed Up and Go test, lower sedentary time, greater perceived control, higher subjective norms, higher life satisfaction, higher career satisfaction, commitment to a plan of exercise, ability to do daily activities, greater enjoyment of PA/exercise, more spare time, better oral-health behaviours, and greater intention to PA/exercise. Some evidence supported associations between higher PA and the following social factors: greater friendship/companionship influences, better hospital staff support, and better information support. Some evidence supported associations between higher PA and the following environmental factors: better physical environment, better supportive neighbourhood environment, a sense of community, less exposure to urban environment, living in a residential community, and shorter distance to shopping place. No evidence was found for policy correlates of PA.

The associations between PA and age, sex, marital status, education level, and household income were mostly non-significant or largely inconsistent.

Sedentary behaviour correlates

The included studies reported associations with SB for a total of 41 variables [32, 42, 45, 46, 56, 67, 79, 80, 83, 89, 93, 97, 102, 109, 116, 117, 119, 120, 122, 124, 126, 143, 155, 161, 162, 182–196]. More than half of them were significantly associated with SB (53.7%; n = 22). In older adults, the included studies investigated only potential SB correlates at the individual level, while they also examined social factors in children and adolescents, and in adults, also environmental factors.

Correlates of children' and adolescents' sedentary behaviour

A total of 19 potential correlates of SB were studied in Thai children and adolescents (Table 5). Some evidence of association with higher SB was found for older age/higher school grade, higher body weight, higher BMI, more physical pain, less participation in sports, more time spent with family, and more participation in extracurricular activities. Non-significant associations with SB were consistently found for sex, being overweight, and obesity.

Correlates of adults' sedentary behaviour

In total, 17 potential correlates of SB were studied in Thai adults (Table 6). A consistent association with SB was found for obesity. Some evidence of association with higher SB was found for being a male, higher education level, low back pain, higher alcohol consumption, lower grade point average, more musculoskeletal symptoms, heavy Internet use, less transport PA, less recreation PA, and more exposure to an urban environment.

Correlates of older adults' sedentary behaviour

Only five potential correlates of SB were studied in Thai older adults (Table 7). No consistent evidence from multiple studies was found on SB correlates in this age group. Some evidence of an association with higher SB was found for obesity, higher alcohol consumption, worse mental health, less active transport, and less recreational PA.

Discussion

Physical activity correlates

A range of factors potentially associated with PA levels in the Thai population were identified at the individual, social,

Table 4 Summary of evidence on physical activity (PA) correlates in Thai older adults (60 years old and above)

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age	104, 139, 164, 191, 192	37, 58, 59, 124, 140	58, 66, 116, 117, 142, 155, 162, 174, 177, 185	??
– Sex (+ denotes males are more active, - denotes females are more active)	66, 100, 155	31, 42, 100, 116, 117, 142, 152, 162, 174, 184, 185	39, 58, 59, 68, 124, 139, 140, 164, 176, 191	??
– Municipality (+ denotes more PA in an urban place of residence, - denotes more PA in a rural place of residence)	58	192	58	?
– Marital status (+ denotes singles are more active)		66, 155	58, 59, 117, 139, 164, 174, 185, 191	??
– Education level	58, 116, 117	40, 59, 139, 142, 155, 162, 164, 185, 192	39, 58, 66, 174, 191	??
– Household income	66, 117	39, 40, 58, 139, 185, 192	58, 59, 142, 162	??
– Occupation (+ denotes unemployed are more active)		155	58, 59, 117	?
– Region (+ denotes Central including Bangkok residents are more active, - denotes residents of other provinces are more active)	134	155		?
– Daily duties (+ denotes individuals performing daily duties regularly are more active, - denotes individuals performing daily duties occasionally are more active)	162			-
– Senior-citizen club membership (+ denotes yes, - denotes no)		139, 191	66	+
– Duration of health club membership			117	?
– Ever attended a workshop on exercise (+ denotes yes, - denotes no)		124		+
Biological factors				
– Body mass index (BMI)			58, 66	?
– Overweight			147 (M, F)	?
– Obesity	47 (M, F)			-
– Bone mineral density (BMD)	42 (F)	99, 134, 138	42 (M)	+
– Skeletal muscle mass (%)			143	?
– Dietary calcium intake		138		+
– Adequate serum vitamin D levels			143	?
– Sunlight exposure		138		+
– Total cholesterol (TCH) level			60 (M, F)	?
– Triglycerides (TG) level	60 (M, F)			-
– HDL-cholesterol level		60 (M, F)		+
– Total cholesterol: HDL-C ratio	60 (M, F)			-
– High TCH			60 (M, F)	?
– High TG	60 (M, F)			-
– Low HDL-C			60 (M, F)	?
– High TCH: HDL-C ratio			60 (M, F)	?

Table 4 Summary of evidence on physical activity (PA) correlates in Thai older adults (60 years old and above) *(Continued)*

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Resting heart rate	166 (M, F)			-
– Mean heart rate			166 (M, F)	?
– Predicted maximum heart rate (%)			166 (M, F)	?
– Systolic blood pressure	161		166 (M, F)	?
– Diastolic blood pressure	161		166 (M, F)	?
– VO_2max		166 (M, F)		+
– FEV1 (Abnormal lung function)			166 (M, F)	?
– FVC (Pulmonary function test)			166 (M, F)	?
– FEV1/FVC (%)			166 (M, F)	?
– Hematocrit level	73			-
– Hypercholesterolemia			103 (M, F)	?
Physical health				
– History of sickness/Underlying illness/Co-morbid diseases (+ denotes yes, - denotes no)	66		59, 162	?
– Having health symptoms (i.e. fatigue, weight loss, sleep disorders) (+ denotes yes, - denotes no)	162			-
– Osteoporosis	138			-
– Age-related macular degeneration (AMD)	88			-
General health				
– Self-rated general health		98, 139, 164, 169, 175	192, 185	++
– Health-related quality of life		41, 48, 56		+
– General oral-health status (e.g. number of teeth, and oral malodour)			152	?
– Periodontal disease	152			-
– Saliva flow rate		152		+
Psychological factors				
– Mental health		32, 43, 98, 175	43	++
– Attitudes towards PA/exercise		79, 117, 188, 191		++
– Self-efficacy		79, 98, 104, 139, 140, 162, 185	39, 53, 174	++
– Perceived benefits of PA/exercise		40, 79, 139, 174, 177, 192	39, 59	++
– Perceived barriers for PA/exercise	39, 40, 79, 139, 176		53, 174	--
– Outcome expectancies		79, 104, 140, 162		++
– Intention to PA/exercise		79, 140		+
– Perceived control		79		+
– Subjective norms		79		+
– Enjoyment of PA/exercise			59	+
– Perceived health risks of exercise	140			-
– Life satisfaction		120		+
– Career satisfaction		182		+
– Motivation for PA/exercise			174	?
– Score on memory and intelligence tests			32	?

Table 4 Summary of evidence on physical activity (PA) correlates in Thai older adults (60 years old and above) *(Continued)*

Correlates	Relationship with PA			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
– Commitment to an exercise plan		53		+
Physical skills, abilities, and fitness				
– Ability to do daily activities		192		+
– Physical and functional fitness (e.g. walking distance, leg strength)		43, 34, 93, 166 (M, F)		++
– Score on Timed Up and Go test	93			-
Health behavioural and lifestyle factors				
– Smoking	66		78 (M, F), 153	?
– Alcohol consumption	66	177 (M)	177 (F)	?
– Sedentary time	58			-
– Spare time		59		+
– Oral-health behaviours (i.e. tooth brushing, and regular dental visits)		152		+
Knowledge				
– Knowledge about PA/exercise		59, 117, 188, 191	162	++
Social environment				
Social and cultural factors				
– Social support		53, 192	98, 162, 174	?
– General interpersonal influences		139	117	?
– Parent/family influences		191, 192	39, 104	?
– Friendship/companionship influences		191, 192	104	+
– Hospital staff support		191		+
– Information support (e.g. from media)		164		+
– Religion (+ denotes Buddhists are more active, - denotes Muslims are more active)		184, 192		+
Physical environment				
Environmental factors				
– Supportive physical environment (e.g. facilities, supplies)		39, 192	117	+
– Supportive neighbourhood environment		39, 40, 104	98	+
– A sense of community		98		+
– Urban environment	100 (M, F)			-
– Residential community (+ denotes rural community is more active, - denotes residential home is more active)		68		+
– Distance to work			58	?
– Distance to the nearest shopping place	58			-
– Distance to the nearest recreation facility			58	?
– Distance to the nearest religious establishment			58	?

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

Table 5 Summary of evidence on sedentary behaviour (SB) correlates in Thai children and adolescents (6 – 17 years old)

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age/School grade		118, 147	91	+
– Sex (+ denotes higher SB in males , - denotes higher SB in females)	147	67, 75, 91, 111, 118, 141	67, 91, 111, 118, 126, 135	??
– Household income		96	75	?
– Parents' marital status			75	?
– Parents' education level			91	?
– Municipality (+ denotes higher SB in an urban place of residence, - denotes higher SB in a rural place of residence)	135 (M)	106	67, 106, 135 (F)	?
Biological factors				
– Body weight		61		+
– Body mass index (BMI)		147		+
– Overweight		111 (F), 171, 157	111 (M, F), 125 (F), 157	??
– Obesity		47 (M, F), 130 (M), 148, 156, 157, 169	33, 96 (F), 130 (F), 157, 173	??
Physical health				
– Asthma			157	?
– Hypertension		157	157	?
– Physical pain		61		+
Health behavioural and lifestyle factors				
– Physical activity participation			178	?
– Playing sports	61			-
Academic/school performance				
– Grade point average	54, 75, 91	61	91, 157	?
Social environment				
Social and cultural factors				
– Time spent with family		61		+
– Good relationship with friends			61	?
– Participation in extracurricular activities		61		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

environmental, and policy levels. However, consistent evidence of association with PA was found only for individual-level and social correlates in children/adolescents and adults and for individual-level correlates in older adults. The summary findings suggest that PA promotion strategies in Thailand need to address several intrapersonal and interpersonal factors and may need to be tailored specifically for different age groups. The lack of consistent evidence from multiple studies for environmental and policy correlates may partially be explained by the fact that most of the included studies assessed individual-level and social correlates only. Future research should, therefore, place more focus on examining potential environmental and policy correlates of PA in the Thai population. Our findings also suggest that correlates of PA in Thailand may be different than in some other countries, calling for more focused, individual-country reviews of this kind.

In the current review, we found consistent evidence for the associations of younger age and male sex with higher PA only in children and adolescents. Among Thai adults and older adults these associations were inconsistent. A previous review for low- and middle-income countries [2] reported "mixed or weak" associations of gender and age with PA, whilst reviews for high-income countries [9, 23, 25] reported consistent associations. This might suggest that socioeconomic context in a given country may play a role in shaping the relationships of age and gender with PA. This should be further explored in future reviews of PA correlates in low- and middle-income countries and individual studies on

Table 6 Summary of evidence on sedentary behaviour (SB) correlates in Thai adults (18 – 59 years old)

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Demographic factors				
– Age		102	84	?
– Sex (+ denotes higher SB in males, - denotes higher SB in females)	84	75, 102, 141		+
– Household income		149	75	?
– Parents' marital status			75	?
– Education level		102		+
Biological factors				
– Underweight			131 (M, F)	?
– Overweight			131 (M, F)	?
– Obesity		46 (M, F), 47 (M, F), 86	46 (M), 131 (M, F)	++
Physical health				
– Musculoskeletal symptoms		85		+
– Low back pain		89, 133 (F)	89	+
– Relative skeletal muscle mass of limbs	105 (F)		105 (M)	?
Health behavioural and lifestyle				
– Having transport and recreation physical activity	58			-
– Heavy internet use		127		+
– Monosodium glutamate (MSG) intake			71	?
– Alcohol consumption		177 (M, F)		+
Academic/school performance				
– Grade point average	75, 84, 149			-
Physical environment				
Environmental factors				
– Urban environment		100		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

Table 7 Summary of evidence on sedentary behaviour (SB) correlates in Thai older adults (60 years old and above)

Correlates	Relationship with SB			Summary Code
	Negative/Inverse (-)	Positive (+)	Non-significant (?)	
Individual Level				
Psychological factors				
– Mental health	43			-
Biological factors				
– Obesity		47 (M, F)		+
Physical skills, abilities, and fitness				
– Functional fitness	43		43	?
Health behavioural and lifestyle factors				
– Engaging in transport and recreation physical activity	58			-
– Alcohol consumption		177 (M, F)		+

(+) Mostly positive associations, (-) Mostly negative associations, (?) Mostly non-significant, indeterminate, or inconsistent associations, (M) Male, (F) Female

gender- and age-specific determinants of PA. Given a relatively large number of studies included in the current review examining the association of PA with age and sex, the lack of consistent evidence in adults and older adults may suggest that the situation in Thailand is indeed different than in some other countries. For most other demographic variables, evidence on their association with PA was scarce or inconsistent in all age groups. More research is needed to understand which demographic characteristics are associated with higher PA levels in Thailand.

Evidence has strongly supported associations between different aspects of health and PA regardless of age [1, 197–200]. Whilst we found evidence on the association of PA with self-reported general health in all age groups and with mental health in adults and older adults, evidence for most other, specific health variables and biological factors was scarce or inconsistent. Moreover, it should be noted that some of the identified health-related variables associated with PA may be outcomes of PA rather than factors affecting PA [201]. For example, it may be that in Thai adults high PA improves general health status, whilst it may also be that healthier Thai adults are more likely to engage in PA. The causality might as well be bidirectional [201]. From the cross-sectional studies included in this review, it was not possible to conclude about the causal direction of the relationships. Clearly, more research is needed on biological and health-related correlates of PA in the Thai population. Furthermore, a large proportion of non-significant associations found between obesity and PA in Thai adults is in accordance with findings of most previous, non-country-specific reviews [6]. Although it may seem reasonable to assume that obese people are less likely to engage in PA, and that more physically active people are less likely to get obese, this association is clearly not so straightforward. Multiple other factors, particularly diet, need to be considered to understand the potential association between PA and obesity.

Previous reviews have identified physical skills, abilities, and fitness as important correlates of PA in all age groups [25, 202, 203]. Based on our review, it seems that this is also the case in the Thai context. It should be noted, however, that findings for nearly every variable in this category are based on results from only one study. Furthermore, findings for behavioural and lifestyle correlates of PA were mixed. We found evidence suggesting that higher PA is associated with past PA/exercise experience in children/adolescents and adults and knowledge of PA/exercise in children and older adults. Providing exercise instructions and opportunities to gain experience in PA/exercise might, therefore, be an effective way to increase PA participation in the Thai population. We also found that having more spare time may be associated with higher PA in adults and older adults. Time management interventions aimed at achieving balanced time use, to ensure enough spare time is available for engaging in PA, may be needed to increase PA levels in the Thai population [7].

It is interesting that consistent evidence of association with PA across all three age groups was found only for two psychological factors; namely self-efficacy and perceived barriers. Our finding regarding self-efficacy is in accordance with previous studies that identified this characteristic as an important determinant of PA behaviour across lifespan; from childhood to older age [2, 9, 25, 204, 205]. Furthermore, perceived barriers for PA are one's evaluations of potential obstacles to start engaging in PA and/or to maintain regular PA (e.g. time constraints, lack of skills, unsuitable weather conditions). Although barriers for PA/exercise may be perceived differently by members of different age groups [206], they seem to be consistently negatively associated with PA behaviour for people of all ages in the Thai population. In previous, multinational reviews, including studies conducted in low-, middle-, and high-income countries, the authors reached inconsistent conclusions with respect to barriers to PA/exercise [2, 9, 24, 25]. For example, whilst Sallis et al. [24] suggested that perceived barriers are significantly associated with PA in children, van der Horst et al. suggested they are not [207]. Similarly, inconclusive findings for adults and older adults have also been reported by other authors [2, 25]. It may be that the association between perceived barriers to PA and PA levels is country-specific. Thus, acquiring country-level evidence may be needed to design effective interventions to tackle perceived barriers to PA.

Social support (e.g. from parents, family, and friends) was identified as a motivator for increased participation in PA, especially for Thai children/adolescents and adults. This is in accordance with findings of previous reviews [2, 9, 24, 208–210]. Interestingly, friend or peer influences have been shown to have a significant direct effect on PA among adolescents, while parents seem to have a more indirect influence [211]. In the current review, we found evidence suggesting that influences from both friends and parents may play important roles in children's/adolescents' engagement in PA. Several studies included in the present review also suggested that parental or family influences may be important correlates of PA in Thai adults. Although only one study showed a positive correlation between friendship/companionship influences and PA in this age group, the evidence should not be ignored, as this was a relatively large study [74]. Social support from friends and companions seem to be an enabler of PA also in Thai older adults. In this age group, support from hospital staff to engage in PA may be important. Therefore, improving different aspects of social support need to be taken into consideration when designing PA strategies and interventions for the Thai population.

Worldwide, a range of environmental attributes have been associated with PA, such as community resources, neighbourhood safety, transportation environment, access to sport and exercise facilities, routine destinations in daily life, and accessibility of public green spaces [2, 9, 18, 24, 25, 208–210, 212–216]. Interestingly, access and proximity to facilities appear to be important contributors to youth PA regardless of country's economic status [2, 9, 24, 208, 209, 216]. Evidence on the associations between most aspects of physical environment and PA in Thai adults is inconclusive. This is mainly because of the limited number of studies conducted on this topic. Some evidence suggests that PA of children/adolescents and older adults in Thailand may be associated with neighbourhood design, which is consistent with findings from other, non-country specific reviews [217, 218]. Given the plethora of evidence from other countries and some evidence from Thailand, it seems important to improve features of the physical environment to increase PA participation in the Thai population. Nevertheless, more studies are needed to investigate environmental correlates of PA that are specific for Thailand.

In terms of policy-related correlates of PA, very few variables have been investigated. Only five studies have examined the effects of policies on PA in Thailand, and were carried out at the local level (i.e. the school and workplace) and among adults [70, 75, 84, 87, 219]. Some evidence suggests that education policies (in specific, university policies) may be associated with PA, whilst a single study did not find a significant association between workplace policies and PA. Further investigations on the potential impact of policies on PA is encouraged.

Sedentary behaviour correlates

A limited number of studies have examined correlates of SB in Thai populations, especially in older adults. Some evidence suggests that, among Thai adults, males engage more in SB than females. This is in accordance with the associations between overall SB and sex found in several other countries [20]. Furthermore, consistent evidence from multiple studies was found for the association between obesity and SB in Thai adults. An umbrella review has suggested that available evidence is not supportive of this association in adults [220]. It might, therefore, be that the findings of the current review reflect only a context-specific situation in Thailand. Based on the available evidence, it seems that interventions for reducing SB should particularly focus on obese individuals, as being obese seems to be associated with more SB. It should be noted, however, that all Thai studies supporting this association are cross-sectional; hence, no inferences can be made about the direction of the relationship. Nevertheless, a previous longitudinal study suggested that obesity may lead to a subsequent increase in SB, whilst there was no evidence for the association in the other direction [221]. Besides, we found mostly non-significant associations between being overweight and engaging in SB. It might, therefore, be that only more severe issues with excessive weight lead to increases in SB. We also found some evidence supporting the association between SB and musculoskeletal disorders. Experiencing bodily pain was associated with higher SB in children and adolescents, whilst having musculoskeletal symptoms and low back pain were associated with higher SB in adults. These findings must be taken with caution, because previous longitudinal studies provided very little evidence in support of such associations [6, 222]. Furthermore, alcohol consumption was found to be associated with increased SB in both adults and older adults. These are, however, findings from one study only (examining both age groups), and given the inconsistent evidence for this association found in a previous review [20], this warrants further investigation. Associations of other variables and SB were either non-significant or supported by a single study, which demonstrates the need for more studies on SB in Thai populations, and particularly in older adults.

Strengths and limitations

This systematic review has several strengths. Most previous reviews of PA/SB correlates did not present country-specific findings. In the current review, for the first time, findings on potential PA/SB correlates in the Thai population were extracted and summarised from many original studies (n = 167). Previous reviews on PA/SB correlates have cited primarily research published in the English language, which may have introduced bias into their findings. In this review, we included publications in both Thai and English; the languages that Thai researchers predominantly use in academic communication. Furthermore, we examined numerous potential correlates, particularly for PA, at all levels—individual, social, environmental, and policy. This comprehensive approach enabled us to better elucidate the complexity of PA and SB behaviours in the Thai population.

This review was not without limitations. Firstly, we did not use a formal meta-analytical procedure to combine the results of individual studies. Given the large number of analysed correlates and great heterogeneity between studies in terms of measures of PA/SB and statistical methods they used, we opted for the procedure for summarising results of individual studies proposed by Sallis et al. [24]. This procedure has been used in several previous systematic reviews in the field of public health. Secondly, relying on evidence from cross-sectional studies has prevented us from drawing conclusions about the direction of the summarised relationships. This was inevitable, because we did not identify any longitudinal studies on factors affecting PA/SB in Thailand. Finally, the findings of this review may have been influenced by recall errors, because the clear majority of included studies relied on self-reported PA/SB, and only a few used devices to assess these behaviours.

Recommendations for future research

A limited number of studies examined SB correlates, particularly for older adults. More research is needed to understand why Thais engage in excessive SB and which factors to address to prevent it. Furthermore, less than one-fourth of all studies on PA correlates were conducted among children and adolescents. These age groups should, therefore, be designated as a priority target for future research on PA correlates. For most correlates of both PA and SB, only few findings from individual studies are available. This is particularly the case for social, environmental, and policy-related variables. More research is needed on most potential correlates of PA and SB in the Thai population. Another challenge stems from the fact that all studies included in this review used cross-sectional designs. To provide evidence on prospective and causal relationships between the variables and PA/SB, longitudinal and intervention studies should be conducted. In addition, to improve the validity of PA/SB estimates and avoid the potential recall bias, subject to feasibility, researchers are encouraged to employ devices, such as accelerometers, pedometers, or multi-sensor measures.

Conclusions

This review is one of the first to summarise within-country correlates of PA and SB across population groups. Given a range of differences between the findings of the current review and the findings of previous non-country specific reviews, it may be important to consider correlates of PA and SB at the country-level. This may be particularly relevant when such reviews are completed to inform national- and local-level public health interventions.

Findings of the current review suggest that several factors are associated with PA levels in the Thai population. Based on the available evidence, to increase PA in Thailand, public health interventions should focus on helping individuals: improve self-efficacy; circumvent perceived barriers for PA; improve general and mental health; find enough spare time to engage in PA; improve physical skills, abilities, and fitness; gain knowledge about and experience in exercise; and receive adequate social support for participation in PA. Furthermore, the body of literature on correlates of SB in Thailand is limited. Nevertheless, evidence suggests that interventions for reducing SB in Thai adults should primarily target obese individuals, as they seem to be at a greater risk of high SB.

More Thai studies are needed on PA correlates, particularly among children and adolescent and with a focus on environment- and policy-related factors. Much greater commitment is needed to investigating correlates of SB in Thailand, particularly among older adults. The Thai Government and public health stakeholders should provide a systematic support to such research, as it provides knowledge that is crucial for designing public health policies, strategies, and interventions.

Additional files

Additional file 1: Data Extraction Table. The detailed table of all data extracted from each study included. (XLSX 67 kb)

Additional file 2: Supplementary Correlate Tables. The additional tables of correlates for individual type of physical activity. (PDF 120 kb)

Additional file 3: Results of the study quality assessment using the Newcastle-Ottawa Scale for cross-sectional studies. The quality assessment score for included studies assessed by Newcastle-Ottawa Scale (NOS). (PDF 349 kb)

Abbreviations

MPA: Moderate Physical Activity; MVPA: Moderate-to-Vigorous Physical Activity; NDLTD: Networked Digital Library of Theses and Dissertations; PA: Physical Activity; SB: Sedentary Behaviour; TV: Television; VPA: Vigorous Physical Activity; WHO: World Health Organization

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The summary of reviewed articles is available in Tables, Figures, and Supplementary materials

Authors' contributions

NL and ZP conceived the idea for the review. NL, ZP, MC, and SJHB conceptualised the review. NL led the writing of the study protocol. NL and ZP designed the strategies for a systematic search. NL and KS conducted the study selection. NL extracted the data, assessed the quality of the studies, and analysed the data. NL drafted the initial manuscript. ZP, MC, SJHB, and KS contributed to writing the manuscript. All authors read and approved the final draft.

Ethics approval and consent to participate

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Competing interests

The authors declare that they have no competing interests.

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METHODOLOGY **Open Access**

Standardised criteria for classifying the International Classification of Activities for Time-use Statistics (ICATUS) activity groups into sleep, sedentary behaviour, and physical activity

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Abstract

Background: Globally, the International Classification of Activities for Time-Use Statistics (ICATUS) is one of the most widely used time-use classifications to identify time spent in various activities. Comprehensive 24-h activities that can be extracted from ICATUS provide possible implications for the use of time-use data in relation to activity-health associations; however, these activities are not classified in a way that makes such analysis feasible. This study, therefore, aimed to develop criteria for classifying ICATUS activities into sleep, sedentary behaviour (SB), light physical activity (LPA), and moderate-to-vigorous physical activity (MVPA), based on expert assessment.

Method: We classified activities from the Trial ICATUS 2005 and final ICATUS 2016. One author assigned METs and codes for wakefulness status and posture, to all subclass activities in the Trial ICATUS 2005. Once coded, one author matched the most detailed level of activities from the ICATUS 2016 with the corresponding activities in the Trial ICATUS 2005, where applicable. The assessment and harmonisation of each ICATUS activity were reviewed independently and anonymously by four experts, as part of a Delphi process. Given a large number of ICATUS activities, four separate Delphi panels were formed for this purpose. A series of Delphi survey rounds were repeated until a consensus among all experts was reached.

Results: Consensus about harmonisation and classification of ICATUS activities was reached by the third round of the Delphi survey in all four panels. A total of 542 activities were classified into sleep, SB, LPA, and MVPA categories. Of these, 390 activities were from the Trial ICATUS 2005 and 152 activities were from the final ICATUS 2016. The majority of ICATUS 2016 activities were harmonised into the ICATUS activity groups ($n = 143$).

Conclusions: Based on expert consensus, we developed a classification system that enables ICATUS-based time-use data to be classified into sleep, SB, LPA, and MVPA categories. Adoption and consistent use of this classification system will facilitate standardisation of time-use data processing for the purpose of sleep, SB and physical activity research, and improve between-study comparability. Future studies should test the applicability of the classification system by applying it to empirical data.

Keywords: ICATUS, Time-use survey, Physical activity, Sedentary behaviour, Sleep, Time-use epidemiology

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Background

Sleep, sedentary behaviour (SB), light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA) are activity-based behaviours associated with a range of health outcomes [1]. For example, short duration of sleep is associated with a higher risk of developing coronary heart disease, stroke, type II diabetes, and certain types of cancer [2–4]. It is suggested that too much SB increases the risk of cardiovascular disease, type II diabetes, and metabolic syndrome [5]. Physical inactivity (usually defined as insufficient amount of MVPA to meet physical activity (PA) recommendations [6]) is also associated with an increased burden of disease, including coronary heart disease, type II diabetes, breast cancer, and colon cancer [7]. Although previous studies examined sleep, SB, LPA, and MVPA as independent predictors of health outcomes, recently, methodological papers suggest these are all mutually exclusive and exhaustive components of the time-finite 24-h day, and should, therefore, be considered as co-dependent variables [8–10]. Recent studies aimed to acknowledge co-dependence of these variables using different analytical approaches, such as isotemporal substitution and compositional data analysis [1, 8, 11–17]. Despite the differences in statistical approaches, there is wide agreement that conceptualising and studying sleep, SB, and PA as integral parts of the 24-h day may lead to novel and important insights into activity-based behaviours and health [8, 10, 18–21]. This new way of conceptualising activity-based behaviours is sometimes referred to as the "Time-Use Epidemiology" paradigm [10].

National time-use surveys have been conducted in over 85 countries worldwide [22]. Time-use survey data have been of great interest for researchers, due to their comprehensiveness and a broad range of possible applications in public health, sociology, economics, and transportation research [23]. It is widely accepted that the validity and reliability of time-use survey data are adequate for large-scale, observational studies [23–29]. Several studies used time-use data to investigate population-level PA patterns [30–36].

Most previous studies in time-use epidemiology have relied on accelerometer-based estimates of sleep, SB, and PA [15, 37–45]. While accelerometers have undoubtedly been providing useful data for time-use epidemiology, they have limitations in terms of validity, generalisability, between-study comparability, and comprehensiveness of movement behaviour estimates [46]. The affordability and sustainability of their use in population surveillance has also been questioned [46]. With complete 24-h data, time-use surveys may be a good alternative to accelerometers, as they also allow researchers to investigate the combined effects of all movement-related behaviours on health [47]. They can also be used to track the prevalence of meeting the new integrative 24-h movement guidelines that include joint recommendations for sleep, SB, and PA [19, 20, 48–51]. However, as time-use surveys were not designed specifically to collect data on PA and SB, their use in time-use epidemiology has been limited. The 24-h movement behaviour data from time-use surveys are, therefore, yet to be explored in detail in relation to health outcomes. To enable this, classification systems for deriving health-related time-use compositions from time-use surveys must be developed and evaluated [25, 52–54]. A recently developed framework entitled Viable Integrative Research in Time-Use Epidemiology (VIRTUE) recognised this as a methodological task of fundamental importance for the further development of time-use epidemiology [10]. The availability of such classification systems is a prerequisite for utilisation of time-use survey data in epidemiological studies on movement-related behaviours.

Response options in time-use surveys are often derived from standardised time-use classification systems. The International Classification of Activities for Time-Use Statistics (ICATUS) is one of the most widely used time-use classification systems. It was developed by the United Nations Statistics Division (UNSD) to provide meaningful and comparable time-use statistics across countries and over time [22, 55, 56]. ICATUS has been used as a framework for several nationally representative time-use surveys, mostly in Asia and Africa [56]. The ICATUS was first introduced as a draft classification in 1997 by the UNSD. In 2000, the expert group carried out further refinements to the activity categories, which was published in 2005 as the Trial ICATUS [55]. Several consultation meetings were organised between 2012 and 2016 among experts and relevant stakeholders to finalise the classification [55]. The ICATUS 2016 is the final version, with a simplified structure and terminologically aligned with existing international standards, such as the System of National Accounts and the International Standard Industrial Classification of All Economic Activities [55]. The Trial ICATUS 2005, a five-level hierarchical classification, is comprised of 15 major divisions, 54 divisions, 92 groups, 200 classes and 363 subclasses. The ICATUS 2016, a three-level hierarchical classification, includes 9 major divisions, 56 divisions, and 165 groups. The Trial ICATUS 2005 has been used in many national time-use surveys since 2000, while the ICATUS 2016 is a finalised classification system for future ICATUS-based time-use surveys [55].

Activity categories from several time-use surveys have previously been classified according to their "Metabolic Equivalent of Task" (MET) [25, 29, 57–61]. One MET describes the human energy expenditure while at rest (i.e., resting metabolic rate or approximately 1 kcal/kg/hour), whilst two METs is twice that at rest [62]. Tudor-Locke and colleagues (2009) assigned MET values to

438 activities in the American Time Use Survey (ATUS) according to the 2011 Adult Compendium of Physical Activities (hereafter called "the Compendium") [25–27, 63]. Several studies have also applied METs using the Compendium in other time-use surveys, such as the Australian Time Use Survey, Statistics Canada's General Social Survey – Time Use (GSS-TU), and Belgian Time Use Survey (using Harmonised European Time Use Survey [HETUS] classification) [29, 58–61, 64]. However, no previous studies have developed criteria for classifying ICATUS activities into sleep, SB, LPA, and MVPA categories.

Like other systems that can classify time-use components into different types of health-related domains (e.g. social activities, cognitive activities), a classification system for classifying the ICATUS activities into major activity-based time-use components (i.e., sleep, SB, LPA, and MVPA) would also enable time-use epidemiologists to process data from many existing and future population-representative surveys. Such a system would also facilitate standardisation of data processing in this area, which may improve between-study comparability. To be able to classify time-use components into sleep, SB, LPA and MVPA, one must know: (i) their MET value; (ii) whether they are done while awake or while asleep; and (iii) in which posture they are performed [6, 10]. However, these three criteria have never been inclusively assigned to any time-use surveys. This study, therefore, aimed to assign MET values and codes for wakefulness status and posture to the Trial ICATUS 2005 and the Final ICATUS 2016 activities to enable their classification into sleep, SB, LPA, and MVPA categories. It can be expected that future studies will predominantly use the Final ICATUS 2016. Nevertheless, it should not be disregarded that the Trial ICATUS 2005 has already been used in many national time-use surveys for over a decade, which means a lot of valuable time-use data is already available. To facilitate comparability between studies based on the Trial ICATUS 2005 and the Final ICATUS 2016 and enable research on trends in movement-related behaviours (which are lacking for many countries), we decided to classify activities from both versions.

Methods

Classification criteria

Criteria used to classify time into sleep, SB, LPA, and MVPA were: 1) relative energy expenditure (MET values from the Compendium [63]); 2) wakefulness (yes or no); and 3) sitting/reclining/lying posture (yes or no). The answer "no" to sitting/reclining/lying posture implied standing or being on one's feet while performing an activity. The ICATUS activities were classified into sleep, SB, LPA, and MVPA categories based on the criteria presented in Table 1. Given that a number of ICATUS activity categories are very broad and non-specific, in many cases it would not be possible to make a clear distinction between moderate and vigorous intensity. We, therefore, combined these two intensity levels into MVPA.

Table 1 Criteria for classifying time-use components into sleep, SB, LPA, and MVPA

Activity-based category	METs	Wakefulness	Sitting/reclining/lying
Sleep	< 1	No	Yes or No
SB	$\geq 1 - \leq 1.5$	Yes	Yes
LPA	$> 1.5 - < 3$	Yes	Yes or No
MVPA	≥ 3	Yes	Yes or No

Notes: MET: metabolic equivalent of task; SB: sedentary behaviour; LPA: light physical activity; MVPA: moderate-to-vigorous physical activity

Initial assessment of ICATUS activities

The initial assessment of activities was done for the Trial ICATUS 2005, because the Trial ICATUS provides a more detailed classification activities than the Final ICATUS. The Trial ICATUS 2005 groups activities into five levels. The first level, 2-digit code or "major divisions" includes the broadest groups of activities, and the fifth level, 6-digit code or "subclasses" represents the most detailed level of the classification [65]. The major divisions and their associated subclass activities of the Trial ICATUS 2005 were entered into a separate Excel spreadsheet. One author (NL) conducted an initial assessment by assigning i) relative energy expenditure (MET values from the Compendium); ii) wakefulness status (yes or no); and 3) sitting/reclining/lying posture (yes or no) to each 6-digit activity in each major division of the Trial ICATUS 2005. When assigning the codes, NL consulted the Guide to Producing Statistics on Time Use which provided definitions and descriptions of ICATUS activities, including examples and exceptions [65]. To assign a MET value, each ICATUS subclass activity was matched with one or more Compendium activities according to the examples and descriptions provided in the above-mentioned documents. The coding rules presented in Table 2 were used in the assessment.

The MET values and codes for wakefulness status and posture were assigned to the most detailed level of activities (i.e., subclass activities). For the activities that are broadly described and encompass more than one specific activity in the Compendium, a median MET value of respective Compendium activities was calculated. The summary MET values were also computed for the 4-digit and 5-digit activities in ICATUS 2005 as a median MET value assigned to their subclasses. Summary wakefulness and posture categories were assigned to each 4-digit and 5-digit activity according to the respective assessments made for the majority of its subclasses. The

Table 2 Coding rules to assign Compendium METs, wakefulness, and posture to the ICATUS activities

Coding rule 1	Assign the codes and MET values from the Compendium and the codes for wakefulness and posture to each 6-digit activity		
Coding rule 2	Use a median MET estimate of the respective activities or subcategories	2a.	when more than one activity from the Compendium was assigned to a 6-digit activity
		2b.	when assigning METs to a 4-digit and 5-digit activity
		2c.	when an activity is classified as "not further defined" (n.f.d.) or "not elsewhere classified" (n.e.c.)
		2d.	when there is insufficient information in the explanatory notes; usually classified as "other related activities" and ends in "9"
Coding rule 3	Assign the codes for summary wakefulness and posture to a 4-digit and 5-digit activity according to the assessments made for the majority of its 6-digit subclass activities		

Notes: Compendium: 2011 Adult Compendium of Physical Activities [63]; MET: metabolic equivalent of task; ICATUS: International Classification of Activities for Time-Use Statistics; n.f.d.: not further defined; n.e.c.: not elsewhere classified

summary assessments were also used for an activity classified as "not further defined" (n.f.d.) or "not elsewhere classified" (n.e.c.) or "other related activities" or ends in "9" activities, where information is insufficient. An extract from the table used in the described assessment process is shown in Table 3, while the complete table can be found in Additional file 1.

MET values and the codes for wakefulness and posture were not assigned to occupational and travel-related activities, because insufficient information is provided in the Guide to Producing Statistics on Time Use [65] and the ICATUS 2016 document [55] to be able to make an informed assessment of these ICATUS activities.

Harmonisation of ICATUS 2005 and 2016 activities

Once all subclass activities of the Trial ICATUS 2005 were coded, one author (NL) matched 3-digit activities (the most detailed level) from the ICATUS 2016 with corresponding activities of the Trial ICATUS 2005, where applicable. The description of the activity codes in the Trial ICATUS 2005 and the ICATUS 2016 [55, 65], including examples and exceptions, was examined for harmonisation purposes. The MET values, wakefulness status, and posture categories assigned to ICATUS 2005 activities were used for their matching ICATUS 2016 activities. For the ICATUS 2016 activities that could not be matched with any ICATUS 2005 activity, we assigned MET values, wakefulness status, and posture separately. Furthermore, some ICATUS 2016 activities were matched with multiple ICATUS 2005 activities. To such activities we also assigned MET values, wakefulness status, and posture separately. An extract from the table used in the described harmonisation process is shown in Table 4, while the complete table can be found in Additional file 1.

Delphi survey

The initial assessment and harmonisation of ICATUS activities were reviewed independently and anonymously by all content experts as part of a Delphi decisional process. The Delphi method consists of a series of anonymous surveys, conducted to achieve a consensus among members of an expert panel, and it is widely used for decision-making [66]. The Delphi survey was conducted using Qualtrics software (Version qualtrics^{XM} of the Qualtrics Research Suite, Qualtrics LLC, Provo, UT, USA), an online survey platform [67]. Content experts were grouped into four panels, each consisting of four members. Each panel reviewed approximately 130 activities. Each panel included: i) the initial assessor (NL), who could provide detailed reasoning for every assessment to the other members of the panel; ii) at least one specialist in SB and/or PA epidemiology; iii) at least one specialist in SB and/or PA measurement; iv) at least one specialist in time-use surveys; and v) researchers from three or more different countries. The Delphi process was moderated by a researcher specialised in SB and PA topics, who was not involved in any of the Delphi panels nor was included in the author team.

At the beginning of the Delphi survey, panellists were given detailed information about the process of classifying the ICATUS activities by METs, wakefulness status, and posture. As part of the survey, each expert panel was asked to review the initial assessments and harmonisation and to express their agreement or provide suggestions for improvement. After each survey round, the moderator summarised the responses from the expert panels and amended the assessments and harmonisation accordingly. The revised list was then circulated among the members of the expert panel as part of the following survey round, to see if any further refinements were needed. A summary report including the original responses from all panel members was sent alongside all subsequent surveys. These steps were repeated until a consensus was reached among all content experts.

An additional panel was formed to review 32 ICATUS 2016 activities that could not be harmonised with a single activity from the Trial ICATUS 2005. We undertook the same Delphi procedures for this additional expert panel as described above.

Results

We assigned MET estimates and codes for wakefulness status and posture to a total of 542 ICATUS activities.

Table 3 An extract from the table used for the assessment of ICATUS 2005 activities

ICATUS 2005				Assessment			Compendium of Physical Activities		
Code			Description	Summary METs	Wakefulness (Yes/No)	Sitting/ reclining/lying (Yes/No)	Code	Major heading: specific activities	METs
1211			Visual, literary and performing arts (as hobby) and related courses	2.75 (median of four subclass activities)	yes	no			
	12111	121110	Visual arts	2.75 (median of respective Compendium activities)	yes	yes	09020	Miscellaneous: drawing, writing, painting, standing	1.80
							09075	Miscellaneous: sitting, arts and crafts, carving wood, weaving, spinning wool, light effort	1.80
							09080	Miscellaneous: sitting, arts and crafts, carving wood, weaving, spinning wool, moderate effort	3.00
							09085	Miscellaneous: standing, arts and crafts, sand painting, carving, weaving, light effort	2.50
							09090	Miscellaneous: standing, arts and crafts, sand painting, carving, weaving, moderate effort	3.30
							09095	Miscellaneous: standing, arts and crafts, sand painting, carving, weaving, vigorous effort	3.50
	12112	121120	Literary arts	1.30 (median of respective Compendium activities)	yes	yes	09040	Miscellaneous: sitting, writing, desk work, typing	1.30
							09060	Miscellaneous: sitting, studying, general, including reading and/or writing, light effort	1.30
							07050	Inactivity quiet/light: reclining, writing	1.30
	12113	121130	Performing arts (dance, music, theatre)	4.00 (median of respective Compendium activities)	yes	no	03031	Dancing: general dancing (e.g. disco, folk, Irish step dancing, line dancing, polka, contra, country)	7.80
							03010	Dancing: ballet, modern, or jazz, general, rehearsal or class	5.00
							10074	Music playing: playing musical instruments, general	2.00
							10130	Music playing: marching band, baton twirling, walking, moderate pace, general	4.00
							10131	Music playing: marching band, playing an instrument, walking, brisk pace, general	5.50
							10135	Music playing: marching band, drum major, walking	3.50
							11870	Occupation: working in scene shop, theater actor, backstage employee	3.00
	1211x		Visual, literary and performing arts n.f.d.	2.75 (summary assessments)	yes	no			

Notes: Compendium: 2011 Adult Compendium of Physical Activities [63]; MET: metabolic equivalent of task; ICATUS 2005: Trial International Classification of Activities for Time-Use Statistics 2005; n.f.d.: not further defined

In Round 1, experts suggested modifying the original assessments of 91 activities and harmonisation of 3 activities. In Round 2, a consensus on the assessment and harmonisation of ICATUS 2005 and ICATUS 2016 activities was reached by two panels. Further suggestions were received to adjust assessments of 31 activities in the remaining groups. In Round 3, a consensus on the assessment and harmonisation of ICATUS 2005 and

Table 4 An extract from the table used for the harmonisation of ICATUS 2005 and 2016 activities

ICATUS 2005				ICATUS 2016	
Code			Description	Code	Description
1511			Sleep and related activities		
	15111	151110	Night sleep/ essential sleep	911	Night sleep/essential sleep
	15112	151120	Incidental sleep/ naps	912	Incidental sleep/ naps
	15113	151130	Sleeplessness	913	Sleeplessness
	1511x		Sleep and related activities n.f.d.	919	Other sleep and related activities
		03111	Processing of food products	127	Making and processing goods for the market in household enterprises
		03112	Making of other food products and beverages		
		03113	Making textiles, wearing apparel, leather and associated products		
		03114	Craft-making using all types of materials		
		03115	Tobacco preparing and curing		
		03116	Making bricks, concrete slabs, hollow blocks, tiles etc.		
		03117	Making herbal and medicinal preparations		

Notes: ICATUS 2005: Trial International Classification of Activities for Time-Use Statistics 2005; ICATUS 2016: International Classification of Activities for Time-Use Statistics 2016; n.f.d.: not further defined

ICATUS 2016 activities was reached for the remaining groups. The experts reached consensus for all activities, except for: 131120 *"biking, skating, skateboarding"*; 131150 *"ball games, team sports"*; and 131160 *"water sports"*. These activities were assigned 7 METs, 7 METs, and 6 METs, respectively; however, one panel member suggested their metabolic values may be higher. For these activities, we made the final decisions in the third round of the Delphi survey, based on 75% agreement between the experts. The flow of the Delphi process and results of each survey round are outlined in Fig. 1.

From a total of 390 activities assessed from the Trial ICATUS 2005, we classified 3 activities into sleep (0.7%), 65 activities into SB (16.7%), 186 activities into LPA (47.7%), and 136 activities into MVPA (34.9%). The summary codes, including the activity-based categories, MET estimates, wakefulness status, and posture assigned to the Trial ICATUS 2005 activities are available in Additional file 2.

Of a total of 152 activities assessed from the final ICATUS 2016, we classified 3 activities into sleep (2%), 32 activities into SB (21%), 69 activities into LPA (45.4%), and 48 activities into MVPA (31.6%). We were able to harmonise a vast majority of ICATUS 2016 activities with ICATUS 2005 activities (n = 143; 94.1%). The summary codes, including the movement categories, MET estimates, wakefulness status, and posture assigned to the ICATUS 2016 activities are provided in Additional file 3. The full assessment and harmonisation tables of ICATUS activities are available in Additional file 1.

Discussion

This is the first study to develop an expert-based classification of ICATUS activities into sleep, SB, LPA, and MVPA categories. We also provided estimated MET values, wakefulness status and posture for ICATUS activities; information that researchers can use for other categorisations (e.g., sleep, SB, LPA, and moderate-vigorous PA). The classification may be considered as the first step towards greater utilisation of ICATUS-based time-use surveys in time-use epidemiology.

To date, it seems that only time-use surveys conducted in high-income countries have been used to estimate SB and PA levels. This includes studies based on ATUS [25, 27, 31, 68–71], American Heritage Time Use Study (AHTUS) [32, 72], GSS-TU [33, 35, 58, 64, 73, 74], Australian Time Use Survey [29, 30, 60, 61], the United Kingdom Time Use Survey [36], Belgian Time Use Survey (using HETUS classification) [51, 59], Multinational Time Use Study (MTUS) [52, 53], Dutch Time Use Survey [75], and Halifax Space-Time Activity Research survey (conducted in Halifax, Nova Scotia, Canada) [57]. To the best of our knowledge, no such studies have been conducted in low- and middle-income countries. ICATUS-based time-use surveys have been conducted in many low-, middle-, and high-income countries [22, 56]. Our results will enable easier utilisation of these abundant data for the purpose of studies in time-use epidemiology. However, more validation studies of time-use surveys for assessing SB and PA are still needed, especially in larger samples and against device-based measures of these behaviours.

It has been suggested that three rounds of Delphi surveys are sufficient to gather key feedback from the panel members [66, 76]. Further rounds are unlikely to provide additional essential information [66, 76]. Percent of agreement between experts in Delphi studies varies from as low as 55 to 100% [77]. In the present study, the panel members reached perfect agreement for nearly all activities in no more than three survey rounds. This indicates that the assignment of MET values, wakefulness status, and posture to ICATUS-based time-use categories was relatively straightforward. However, a number of

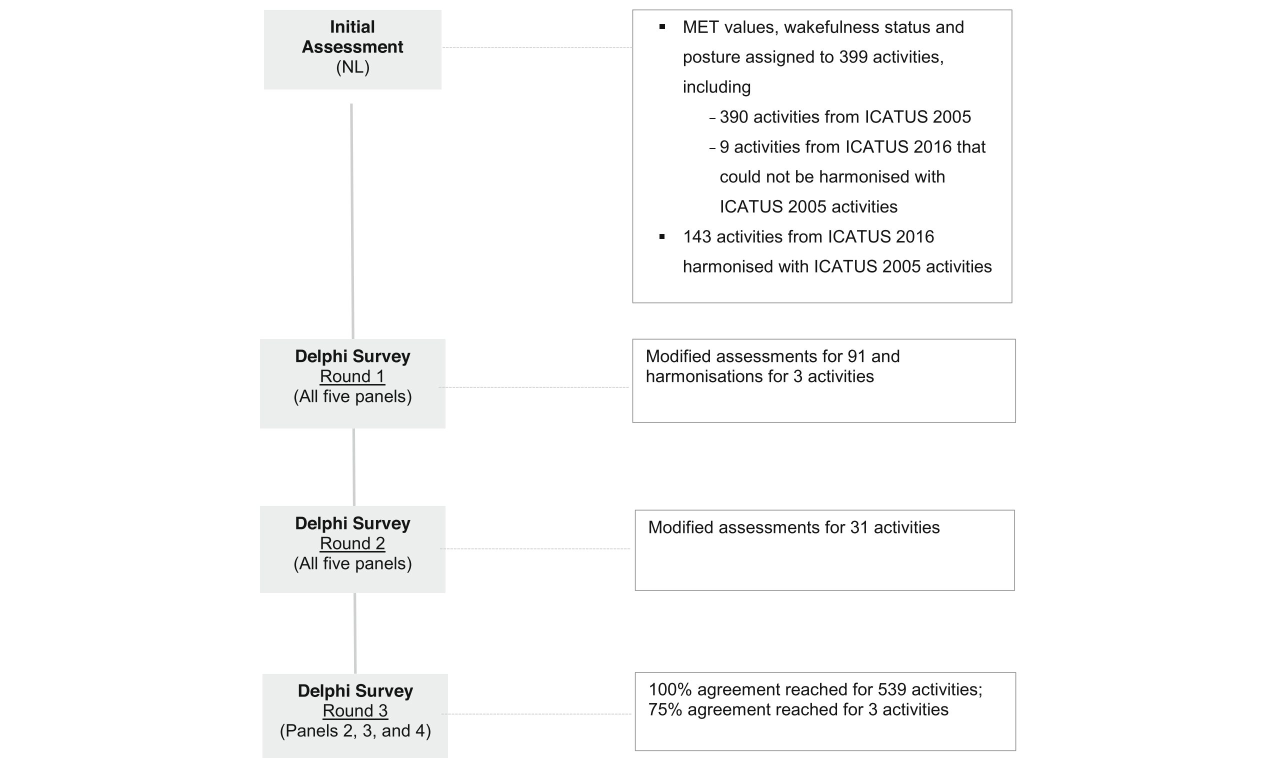

Fig. 1 Flow and results of the Delphi process

points were raised by experts during the Delphi process, which shows the importance of using a collective (vs individual) approach when developing criteria for classifying time use into activity-based categories. It is possible that more rounds of Delphi surveys would be needed, if the panels included additional members. On the other hand, a large number of points to assess (as in the current study) generally makes reaching consensus more difficult.

Historically, time-use surveys were designed to capture a population's time budget reflecting on social and economic perspectives such as labour force, unpaid work, work life balance, and gender equality [55]. Estimating MET values for some ICATUS activities was impossible or very challenging. Firstly, there are several broad categories in ICATUS that consist of a wide range of different activities. It was difficult to assign a specific MET value to such categories. For example, the activity 131110 *"walking and hiking; jogging and running"* under group 1311 *"participating in sports"* includes four main activities; namely, walking, hiking, jogging, and running, that can be associated with varying intensities ranging from 3.0 METs (Compendium code 17170 *"walking, 2.5 mph, level, firm surface"*) to 23 METs (Compendium code 12135 *"running, 14 mph (4.3 min/mile)"*) [63]. Secondly, assigning METs to ICATUS activities in the *"working time in formal sector employment"* (Major division 01 employment) and the travel-related activities was not possible due to insufficient information about these activities. In ICATUS, these activities are classified generally as "working time" and "travel-related" activities. For example, ICATUS code 011110 is defined as "working time in main job". It is obvious that "working time" defined in such an unspecific way can include any type of work, which can be completely sedentary or extremely physically demanding. Similarly, "travel-related activities" can include any kind of transport, including its active (e.g., cycling) and passive (e.g., going by train) modes. In the current study, these activities were, therefore, coded as "not applicable". However, for future users of ICATUS-based time-use data, it may be possible to estimate associated METs of these activities, if the participants' responses are linked with additional, more specific questions about their occupation and modes of travel [23]. Such additional questions are often included in time-use surveys [23]. Once these variables are linked, MET estimates can be assigned using the Compendium [63] or from summary MET values previously assigned to a list of occupations [23, 25, 26, 58]. Similar difficulties were also reported in previous studies by Tudor-Locke et al. [25] and Spinney et al. [58].

There are several strengths of the current study. Firstly, the Delphi panellists were purposefully selected to participate in the study based on their expertise in relevant research fields. Secondly, Delphi panels were formed in a way to ensure representation of varying skills and experience in each panel. Thirdly, we categorised both ICATUS 2005 and ICATUS 2016 activities, which will enable SB and PA researchers to use ICATUS-based time-use data collected over a period of nearly 15 years. Lastly, our harmonisation of ICATUS 2005 and ICATUS 2016 activities will improve the comparability of the derived SB and PA data from the two ICATUS versions.

There are also some limitations in the present study. First, as we needed experts with relevant knowledge in different fields, we included 13 content experts to participate in the Delphi survey. As they were divided into four experts per one Delphi panel, the number of Delphi panellists in this study may be considered small. Despite our effort to recruit panellists with expertise in different areas, it is possible that their consensus does not represent the broader field. It may also be that the relatively small number of panel members negatively impacted the validity of final outcomes of the Delphi process. Another limitation of the study is that we assigned an unweighted median MET value to most ICATUS activities, calculated from the list of matched Compendium activities. A more precise estimation could be achieved by calculating weighted averages, where the weights are proportional to the representation of these activities in the time use of a specific population. This approach has been used with data from the MTUS [53], but it depends on an underlying dataset giving the prevalence of component activities. Given that we did not have access to such data as part of this study and that our study was not intended to focus on a specific population, we provided generic, non-weighted estimates. Furthermore, the MET values we used from the Compendium quantify energy costs of physical activities in healthy, 18–65 year old adults [63]. The MET values applied to ICATUS activities should not be interchanged with those identified in the Compendium. Therefore, our estimates are only applicable to healthy adults for analysis of ICATUS data. Detailed tables, including the lists of matched activities from the Compendium and calculations of summary METs are available in Additional file 1, if any adaptations to a specific population is required in future studies.

Conclusion

In this study, a group of 13 content experts in measurement, epidemiology and time use reached a consensus about the estimated MET values, wakefulness status and posture of ICATUS 2005 and ICATUS 2016 activities. This has enabled categorisation of ICATUS activities into sleep, SB, LPA, and MVPA categories, which may encourage greater utilisation of data from time-use surveys in public health research. The generic estimates and categorisations we provided may be used or further adapted to better reflect the time-use patterns of specific study populations. Future research needs to assess the validity and reliability of SB and PA estimates from ICATUS-based time-use surveys. Provided the measurement properties are adequate, the new categorisation system can then be used in studies exploring the patterns, trends, determinants, and outcomes of sleep, SB, LPA, and MVPA.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s12966-019-0875-5.

Additional file 1. ICATUS Assessment and Harmonisation Tables. The full assessment and harmonisation tables of ICATUS activities.

Additional file 2. 2005 ICATUS Assignment Table. Metabolic equivalent (MET) values, summary codes and movement categories assigned to 2005 International Classification of Activities for Time-Use Statistics (ICATUS) activities.

Additional file 3. 2016 ICATUS Assignment Table. Metabolic equivalent (MET) values, summary codes and movement categories assigned to 2016 Inte.rnational Classification of Activities for Time-Use Statistics (ICATUS) activities.

Abbreviations

AHTUS: American Heritage Time Use Study; ATUS: American Time Use Survey; GSS-TU: Statistics Canada's General Social Survey – Time Use; HETUS: Harmonised European Time Use Survey; ICATUS: International Classification of Activities for Time-Use Statistics; ISCO: International Standard Classification of Occupations; LPA: Light Physical Activity; MET: Metabolic Equivalent of Task; MTUS: Multinational Time Use Study; MVPA: Moderate-to-Vigorous Physical Activity; PA: Physical Activity; SB: Sedentary Behaviour; SIC: Standard Industry Codes; SOC: Standard Occupational Classification; TOPAQ: Tecumseh Occupational Physical Activity Questionnaire; UNSD: United Nations Statistics Division; VIRTUE: Viable Integrative Research in Time-Use Epidemiology

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Authors' contributions

NL and ZP conceived the idea for the study. NL led the writing of the study protocol. NL, ZP, MC, SJHB, DD, CTL, BA, CJ, TPvT, UL, DW, DB, and TO conceptualised the study. NL conducted the initial assessment and harmonisation of ICATUS activities. NL, ZP, MC, and SJHB designed the Delphi survey. ZP conducted a review of the initial assessment and harmonisation for a pilot sample of ICATUS activities. NL, ZP, MC, DD, SJHB, CTL, BA, CJ, TPvT, UL, DW, DB, and TO participated as panel members in the Delphi decisional process. NL classified the ICATUS activities and prepared summary Tables. NL drafted the manuscript. ZP, MC, DD, SJHB, CTL, BA, CJ, TPvT, UL, DW, DB, and TO contributed to writing the manuscript. All authors read and approved the final draft.

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