Associations of Sarcopenia Components with Physical Function, Health-Related Quality of Life and Nutrition in Older Adults Performing Exercise Training

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Abstract

Background: Sarcopenia is an ageing-related muscle disease that can be prevented and treated with exercise, particularly resistance training. The purpose of this project was to explore prevalence of sarcopenia and its associations with physical function, physical activity, health-related quality of life (HRQoL) and nutrition in Australian older adults participating in exercise programs at four gyms operated by Uniting AgeWell, Melbourne. It also examines associations with HRQoL in older adults in the United States (US) participating in exercise programs at the University of Texas at El Paso.

Methods: A total of 105 older Australian community-dwelling adults (mean ± SD 76.9 ± 6.2 years), who were already undergoing resistance training, and 85 US community-dwelling adults (mean ± SD 67.7 ± 6.8 years) were assessed for sarcopenia components. The Melbourne analysis included appendicular lean mass (ALM) (assessed using dual energy X-ray absorptiometry; DEXA), muscle strength (assessed by handgrip strength and chair stands) and physical performance (assessed by gait speed, short physical performance battery [SPPB], timed up and go [TUG] and 400-metre walk [400mW] tests). Spearman correlations explored associations for sarcopenia components with self-reported function (via SARC-F), HRQoL (via Assessment of Quality of Life [AQoL-4D], physical activity (via Physical Activity Scale for Elderly [PASE]), and nutrition (via Australian Eating Survey [AES]). The US analysis of historical (2016) data also included DEXA's ALM, muscle strength (assessed by handgrip strength) and physical performance (assessed by gait speed and TUG) and HRQoL (assessed by AQoL-4D) to match the Melbourne study.

Results: Sarcopenia prevalence in the Melbourne cohort was 3.8% according to Foundation for the National Institutes of Health (FNIH) sarcopenia project and the revised European Working Group on Sarcopenia in Older People (EWGSOP2) definitions, and 10.5% according to EWGSOP1. Slower chair stand times were associated with poorer HRQoL ($p = 0.043$), as were TUG and 400mW ($p < 0.01$). Slower TUG and 400mW were also associated with lower physical activity ($p = 0.018$ and $p = 0.035$, respectively). Positive associations were observed for gait speed with HRQoL ($p = 0.001$) and PASE ($p = 0.048$), handgrip strength with PASE ($p = 0.032$), ALM/BMI with PASE ($p = 0.030$) and ALM ($p < 0.05$) and ALM/BMI ($p < 0.01$) with protein and energy intake. Australian Recommended Food Score (ARFS) was not

associated with any of the sarcopenia components. Sarcopenia was only detected by the FNIH definition in the US sample (7.1%) and no significant associations were observed for sarcopenia components with HRQoL before and after the exercise intervention (all $p > 0.05$). **Conclusion:** Sarcopenia prevalence in older adults participating in supervised exercise programs was low and varied according to the definition applied. A universally accepted definition of sarcopenia is recommended to enable consistent diagnosis and implementation in clinical settings. Due to low prevalence of sarcopenia at baseline in the El Paso cohort, it has not significantly changed by exercise, however significant changes were observed in sarcopenia components. Strength training significantly contributed to muscle strength, mass, function, and HRQoL. Power/agility training only to muscle strength and function. It can be concluded that exercises, particularly ST, can improve sarcopenia components and HRQoL in community-dwelling older adults. Sarcopenia components have inconsistent associations with poorer HRQoL in community-dwelling older adults, perhaps indicating that the effects of sarcopenia on HRQoL are most pronounced in older age. Ensuring maintenance of adequate nutrition and non-supervised physical activity may enhance the benefits of supervised training for older adults.

Keywords: health-related quality of life, Helsinki University Research, older adults, power training, resistance training, sarcopenia, strength training

Student Declaration

I, Ewelina Akehurst, declare that the Master by Research thesis entitled 'Associations of sarcopenia components with physical function, health-related quality of life and nutrition in older adults performing exercise training' is no more than 60,000 words in length including quotations and excluding 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.

Signature  Date 14.10.2019

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List of Abbreviations

1RM	one repetition maximum
400mW	400-metre walk
ACEIs	angiotensin II converting enzyme inhibitors
ACSM	American College of Sports Medicine
ADL	activities of daily living
AES	Australian Eating Survey
ALM	appendicular lean mass
ANOVA	analysis of variance
ANZSSFR	Australian & New Zealand Society for Sarcopenia & Frailty Research
AQoL-4D	Assessment of Quality of Life
ARFS	Australian Recommended Food Score
BCAA	Branched-Chain Amino Acids
BDM	bone mineral density
BIA	bioelectrical impedance analysis
BMC	bone mineral content
BMI	body mass index
BMR	basal metabolic rate
BONEM	bone mass
DEXA	dual energy X-ray absorptiometry
EQ-5D	EuroQol-5 dimension
EWGSOP	European Working Group on Sarcopenia in Older People
F-A-C-S	Find-Assess-Confirm-Severity
FATM	fat mass
FATP	fat percentage
FFM	fat free mass
FNIH	Foundation for the National Institutes of Health
GH	growth hormone
HEI	Healthy Eating Index
HRQoL	health-related quality of life
HUR	Helsinki University Research
ICD-10-CM	International Classification of Disease, Tenth Revision, Clinical Modification

ISSN	International Society of Sports Nutrition
IWGS	International Working Group on Sarcopenia
kJ	kilojoules
MDS	Mediterranean Diet Score
MPS	muscle protein synthesis
PAL	physical activity level
PASE	Physical Activity Scale for the Elderly
PMM	predicted muscle mass
PROs	patient-reported outcomes
PT	power/agility training
QoL	quality of life
RDA	recommended dietary allowance
RM	repetition maximum
ROM	range of motion;
RFS	Recommended Food Score
SARC-F	sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls
SARM	selective androgen receptor modulator
SarQoL®	sarcopenia and quality of life
SF-36	36-item short form survey
ST	strength training
TUG	timed up and go
US	United States
UTEP	University of Texas at El Paso

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Chapter 1: Introduction

Skeletal muscle mass and strength decrease with age in a condition described as sarcopenia (Cruz-Jentoft et al., 2018; Rosenberg, 1989, 2011). It can lead to reduced mobility, falls, fractures and loss of independence, resulting in poor quality of life (QoL). If undiagnosed and untreated, it can become life-threatening (Falcon & Harris-Love, 2017; Rosenberg, 2011; Scott et al., 2017; Tang et al., 2018). Sarcopenia was formally recognised as a muscle disease in the United States (US) and given an 'International Classification of Disease, Tenth Revision, Clinical Modification' (ICD-10-CM) code in 2016 (Anker, Morley & Haehling, 2016; Falcon & Harris-Love, 2017), with Australia following suit on 1 July 2019. Due to its effect on health and health-related quality of life (HRQoL), it has been recommended that physicians screen for sarcopenia in both community and geriatric environments (Cruz-Jentoft et al., 2014). However, a barrier to this has been its lack of a universally accepted definition. Major European (European Working Group on Sarcopenia in Older People; EWGSOP) and US (Foundation for the National Institutes of Health; FNIH) definitions based on muscle/lean mass and performance variables differ in recommended cut-points and approach. Although there is no universally accepted definition for sarcopenia, low muscle strength, muscle mass and physical performance are key risk factors for frailty, falls and mortality (Landi et al., 2011, 2012, 2016; Sarodnik, Bours, Schaper, van den Bergh & van Geel, 2018; Skelton, Greig, Davies & Young, 1994; Suetta et al., 2019). Given sarcopenia has only recently received official disease status—despite the term being initially coined by Rosenberg in 1989—treatments, particularly pharmacological, are few in number. As a result, nutrition and exercise have been the mainstay treatments. The benefits of nutrition (particularly protein) have been reported alone and in conjunction with resistance training (Hanach, McCullough & Avery, 2019; Liao et al., 2017, 2019) to prevent and treat sarcopenia (Liao et al., 2019).

Aged-care providers regularly provide access to exercise programs for older residents (Australian Ageing Agenda, 2016; Hewitt, Goodall, Clemson, Henwood & Refshauge, 2018; Hewitt, Refshauge, Goodall, Henwood & Clemson, 2014; Uniting AgeWell, 2019), but there are limited data on the prevalence of sarcopenia in individuals participating in these programs. There are also limited studies that have explored associations of sarcopenia components with self-reported physical activity,

HRQoL and nutrition in older adults using the revised EWGSOP2 (Su, Hirayama, Han, Izutsu & Yuki, 2019). To the best of my knowledge, there are no studies using the new 400-metre walk (400mW) as part of EWGSOP2.

Due to the lack of direct comparison studies of different screening tools for sarcopenia in the literature, there is need to evaluate their performance in more diverse populations to reach a consensus on the most effective tool for use in clinical settings (Nawi & Yu, 2019). This project incorporates two studies using different types of exercise training in diverse populations. Study 1 is a new observational study of lightly and voluntarily physically active community-dwelling older adults that undertook gym-based exercise training for about a year at Uniting AgeWell in Melbourne. Uniting AgeWell is a not-for-profit aged-care provider in Australia offering allied health and therapy, including rehabilitation, health promotion and maintenance programs, including Helsinki University Research (HUR) gyms and conventional gyms, specifically designed for seniors and supervised by physiotherapists or exercise physiologists (Uniting AgeWell, 2019). Most Uniting AgeWell's clients (aged 65 years and over) access the seniors' gym via Commonwealth home support funding, which is provided by the federal government for entry level services into aged care. Consequently, they pay a small contribution for their attendance. However, there are also some clients who pay full fee for these services or their home care package pays. None of Uniting AgeWell's allied health services are registered with public Medicare insurance, thus clients are unable to claim their gym memberships through either the public or private health systems. The purpose of this cross-sectional study was to determine the prevalence and examine associations of sarcopenia components with self-reported function, physical activity, HRQoL and nutrition in older adults performing exercise training. Participants had the opportunity to obtain a clinical body composition scan (dual energy X-ray absorptiometry; DEXA), a body composition report from the bioelectrical impedance analysis (BIA) scale and a personalised nutritional report from the Australian Eating Survey (AES). These provided them with an improved understanding of their own body composition, muscle, fat mass, bone and nutritional health. The study does not aim to interfere with the current bespoke exercise prescription occurring in the gyms. However, it is anticipated that this project will enable the aged-care provider to standardise fitness, body composition and HRQoL assessments across gym sites, and enhance the quality of exercise services. This will support maintaining their clients' positive outcomes, HRQoL and independence to perform activities of daily living (ADL), such as

showering, dressing or climbing stairs. The study also aims to use the research outcomes to raise awareness of sarcopenia and build upon existing evidence supporting resistance training interventions to improve health and HRQoL outcomes for those with, or at risk of, sarcopenia. Ongoing data collection and analysis are recommended, as there are few longitudinal studies in this area.

Study 2 is an analysis of historical data from a research project conceived and conducted by Professor Sandor Dorgo at The University of Texas in El Paso (UTEP). This study was part of UTEP's Physical Fitness in the Golden Age program among previously physically inactive and sedentary community-dwelling older adults in the El Paso region, supervised by research assistants in laboratory settings. This is an ongoing study, including cardiovascular exercises, muscular strength activities, balance and flexibility, following American College of Sports Medicine (ACSM) guidelines. A particular focus of this study was to test for any difference in sarcopenia prevalence or changes in fitness attributes in a group undergoing power training compared to a group undergoing standard strength training. While the strength (ST) group performed added cardiovascular and balance exercises, the power training (PT) group performed muscular power exercises, agility and mobility drills.

The extent to which the different training types and locations of these two studies altered the components of sarcopenia and its association with HRQoL will be examined. However, direct comparison will not be made due to the variance in training methods and participants not being adequately matched. Both studies offer opportunities to research superior ways to improve the health of older adults. This will benefit the respective organisations, clients, practitioners and exercise therapists. They will be provided with evidence-based research regarding healthy ageing and established training programs at Uniting AgeWell, Melbourne and UTEP, El Paso. Gym users received feedback on their progress, but this does not specifically measure sarcopenia components and HRQoL. Improved sarcopenia components should reduce the incidence of sarcopenia, with resultant health benefits. Routine testing may identify the development of sarcopenia in its preliminary stages, enabling participants to discuss the results with their doctors and access appropriate guidance and treatment if necessary. This study introduced some standard strength, physical capability and body composition measures that have been shown to be linked with poor function and increased risk of sarcopenia, such as low handgrip strength, poor balance, slow gait speed, low lean mass and poor HRQoL.

Chapter 2: Literature Review

This review is organised around five concepts that surround sarcopenia, including interventions to combat sarcopenia and its effects on HRQoL. These are ageing, sarcopenia, HRQoL, resistance training incorporating HUR, strength training and power training, and nutrition.

2.1 Ageing

Like most developed countries, Australia's population is ageing due to sustained low fertility, resulting in proportionately fewer children, and increasing life expectancy, resulting in proportionately more older adults (aged 65 years and over) (Australian Bureau of Statistics, June 2018). In 2016, there were about 3.7 million older Australians or in other words 15% (i.e., one in seven Australians) was 65 years old or over. By 2056, it is expected that the older population will increase to 8.7 million (22%) (Australian Institute of Health and Welfare, 2018a, 2018b). Consequently, that group is projected to surpass children in number (under 15 years of age) by around 2034 (Australian Bureau of Statistics, June 2018). Over the next decade, the 'baby boomer' generation (born 1946–1964) will be more than 65 years old, which will create a substantial strain on health, aged-care and medical infrastructure in Australia (Australian Bureau of Statistics, June 2018). Similar growth and proportions exist in the US. In the US, more than 10,000 Americans turn 65 every day. With increasing life expectancy, there were 47.8 million older adults (> 65 years) in 2015, which is about 15% of the total population (US Census Bureau, 2017, May). By 2030, it is projected that there will be 74 million older adults (Centres for Disease Control and Prevention, 2014) and by 2060, 98.2 million (i.e., almost one in four US residents; US Census Bureau, 2017, May).

Older adults need sufficient levels of balance, strength and power to perform ADL—for example, stair climbing and descending (Muehlbauer, Besemer, Wehrle, Gollhofer & Granacher, 2012). Ageing is associated with less muscle and bone mass and more fat mass, affecting muscle strength and functional performance (Baumgartner, 2000). The three key components of body composition; bone, fat and lean mass can be used to assess the risk of physical disability (Chodzko-Zajko & Medicine, 2014). Chodzko-Zajko & Medicine (2014) report that age-related loss of bone mass may lead to a bone fracture, particularly the hip, that limits physical function, resulting in a loss of independence (see Figure 2.1). They argue that obesity can have direct and indirect pathways to physical disability. Excessive body fat is associated with reduced mobility and increased risk of physical disability and can result in chronic diseases, treatment of which can negatively affect body composition and function (e.g.,

cancer and radiation) (Chodzko-Zajko & Medicine, 2014). Declines in lean mass are associated with reduction in muscle strength, power and endurance in older adults (Chodzko-Zajko & Medicine, 2014). People with excess body fat and insufficient muscle mass (sarcopenic obesity) are at the highest risk of physical disability (Chodzko-Zajko & Medicine, 2014).

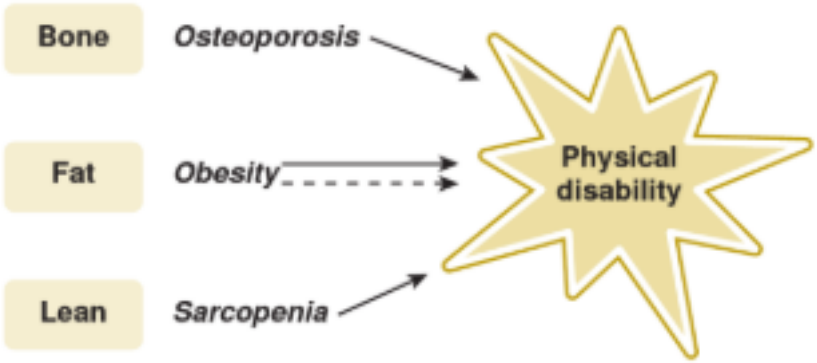

Figure 2.1. Pathway from main components of body composition to physical disability in older adults

Reprinted from Chodzko-Zajko & Medicine (2014, p.152)

Physical disability is a major concern for older adults due to loss of mobility and independence or inability to perform ADL (Chodzko-Zajko & Medicine, 2014). In 2014, one in four older US residents reported a fall, resulting in 74 deaths every day and loading the healthcare system with over US$31 billion in medical expenses (Centres for Disease Control and Prevention, 2014). Loss of independence is a major cause of poor QoL (Al Snih et al., 2007). Successful ageing is multidimensional, including physical, functional, psychological and social health (Chatterjee, 2019; Phelan, Anderson, Lacroix & Larson, 2004). Exercise has been shown to reduce pain and joint stiffness, maintain muscle strength, prevent functional decline and enhance physical and mental health and HRQoL (American College of Sports Medicine, 2014; Bean, Vora, & Frontera, 2004; Buffart et al., 2017; Klaperski, Koch, Hewel, Schempp, & Müller, 2019; Ruegsegger & Booth, 2018; Warburton, Nicol, & Bredin, 2006). Thus, while ageing is inevitable and associated with poorer health, this gradual decline can be slowed by engaging in physical activity and appropriate nutrition as described below.

2.2 Sarcopenia

With age, bone, muscle mass and strength decrease, which if substantial is known as sarcopenia (Cruz-Jentoft et al., 2018; Rosenberg, 1989, 2011). Sarcopenia was originally defined as a loss of muscle mass with age (Rosenberg, 1989). As such, Clark and Manini (2008) recommended this original definition of sarcopenia (loss of muscle mass) and considered

dynapenia (loss of muscle strength) separately due to disassociations between muscle mass and strength, as loss of muscle strength and not loss of muscle mass is a better predictor of mobility impairments (Visser et al., 2000). Although muscle mass is important for metabolic balance, neuromuscular function is important for maintaining muscle strength and physical independence in older adults (Clark & Manini, 2010). With ageing, the decline in muscle strength occurs much faster than the reduction in muscle mass, leading to a deterioration in muscle quality (Goodpaster et al., 2006). Further, retaining or gaining muscle mass does not prevent age-related regression in muscle strength (Goodpaster et al., 2006). Despite this, sarcopenia, incorporating both a loss of mass and function, has become the recognised term (Rosenberg, 2011) and will be used exclusively throughout this thesis.

Sarcopenia can lead to reduced mobility, falls, fractures and loss of independence and can become life-threatening if undiagnosed and untreated (Falcon & Harris-Love, 2017; Lindström et al., 2019; Rosenberg, 2011; Scott et al., 2017; Tang et al., 2018). According to EWGSOP1, sarcopenia is associated with falls (Beaudart et al., 2017; Scott et al., 2017), consequently hospitalisation (Beaudart et al., 2017) and the costs associated with hospitalisation (Antunes, Araújo, Veríssimo & Amaral, 2017). Using a sarcopenia screening test (Ishii's formula based on age, calf circumference and handgrip strength), sarcopenia is a significant predictor of 3-year (Tang et al., 2018), or even 9.5-year all-cause mortality in Australian community-dwelling older women (Sim et al., 2018), and over 10 years in Italian community-dwelling older adults, both using EWGSOP1 criteria (Landi et al., 2016).

It is suggested that sarcopenia be regarded as a 'geriatric syndrome' since it assists in identifying and treating this condition despite unknown causes (Cruz-Jentoft et al., 2010). Geriatric syndrome embraces clinical conditions in older adults that do not cover discrete disease categories—for example, delirium, falls, frailty and dizziness (Inouye, Studenski, Tinetti & Kuchel, 2007). Factors that support the concept of sarcopenia as a geriatric syndrome are its high prevalence in older adults; its contributors (ageing, poor diet, sedentary lifestyle, chronic diseases and drug treatment); and its association with poor states of health (mobility disorders, limitations in performing ADL, greater risk of falls, fractures, disability, independence and mortality (Cruz-Jentoft et al., 2010). Sarcopenia is a public health problem for older adults in the US and significantly more likely to be associated with physical disability (Baumgartner et al., 1998; Janssen, Shepard, Katzmarzyk & Roubenoff, 2004). In 2000, sarcopenia cost US$18.5 billion: that is, 1.5% of total annual US healthcare expenditure (Janssen et al., 2004).

Due to its effect on QoL, physicians should screen for sarcopenia in both community and geriatric environments (Cruz-Jentoft et al., 2014). However, a barrier to this has been the lack of

a universally accepted definition, despite most recent definitions using similar parameters including gait speed or grip strength, in conjunction with low muscle mass, but using different cut-off points (Morley & Malmstrom, 2014). Sarcopenia was formally recognised as a muscle disease in the US and given an ICD-10-CM code in 2016 (Anker et al., 2016; Falcon & Harris-Love, 2017). Australia followed suit on 1 July 2019 (Australian Consortium for Classification Development, 2019), which should lead to increased awareness, diagnosis and interest in treatments.

Examples demonstrating the increase of sarcopenia with age can differ between gender or within ethnic groups and be affected by lifestyle. For example, in New Mexico (US), sarcopenia grew from 13–24% in people under 70 years, to more than 50% in those aged over 80 years. This growth was slightly larger in the Hispanic population (58% in men and 60% in women) than in non-Hispanic white populations (53% in men and 43% in women) (Baumgartner et al., 1998). Using similar body mass measurements among Connecticut's Caucasian population, sarcopenia increased to 53% in men and 31% in women aged over 80 years (Iannuzzi-Sucich, Prestwood & Kenny, 2002). In Mexico City, Mexico, 18% of men and 15% of women aged over 70 were sarcopenic (Espinel-Bermúdez et al., 2017). Within Asian countries, sarcopenia prevalence among hospitalised older adults in western China was similar among men (71%) and women (65%) (Tang et al., 2018). In Taiwan, 26% of men and 19% of women over aged 80 years were sarcopenic (Chien, Huang & Wu, 2008). Using the recent EWGSOP2 definition, there was no significant difference between sarcopenia prevalence and gender (10.1% in men and 7.2% in women) among Japanese community-dwelling older adults living in a snow-covered city (Su et al., 2019). Within Europe, sarcopenia was prevalent in 12% of Danish women aged over 70 years (Tankó, Movsesyan, Mouritzen, Christiansen & Svendsen, 2002). According to EWGSOP1, prevalence of sarcopenia was quite common among Italian octogenarians, showing an increase from 3–32% in women and from 1.2–17% in men (Volpato et al., 2013). Lifestyle difference can also affect sarcopenia prevalence. For example, a systematic review reported that according to EWGSOP1, prevalence of sarcopenia in older adults was up to 29% in community-dwelling settings, up to 33% in long-term care and 19% in acute hospital care (Cruz-Jentoft et al., 2014).

Much research shows discrepancies between sarcopenia prevalence when using different criteria (Dam et al., 2014; Schaap, van Schoor, Lips & Visser, 2017). For example, sarcopenia prevalence greatly ranged across six definitions; two were based on low lean mass alone using criteria of Baumgartner and Delmonico and the other four on both low muscle mass and decreased muscle function (FNIH, EWGSOP, IWGS and Society or Sarcopenia, Cachexia and Wasting Disorders [SCWD]) in 387 community-dwelling older adults, Liège, Belgium (Beaudart et al.,

2018). The lowest sarcopenia prevalence of 4.39% was identified according to SCWD, 10% was identified according to FNIH, under 15% according to EWGSOP, under 30% according to Baumgartner's criteria and the highest of 32.8% according to Delmonico's definition (Beaudart et al., 2018). Beaudart et al. (2018) argue that having many operational definitions for sarcopenia can lead to major public health issues due to over- or underestimation of sarcopenia prevalence, thus, prescribing unnecessary treatment to people without sarcopenia or depriving others that need it most. Potentially, more people will be diagnosed with sarcopenia using EWGSOP1 than FNIH since the criteria for low handgrip (< 30 v. < 26 kg) are less conservative and, if gait speed is low, people without low handgrip strength may still be assessed as sarcopenic (Scott et al., 2017). Recommended FNIH cut-off points applied in this study have no gait speed assessment (Studenski et al., 2014). However, gait speed is important to assess physical function since it is a predictor of falls in older adults (Liang et al., 2014; Scott, Hayes, et al., 2014; Scott, McLaughlin, et al., 2014; Scott et al., 2017), disability and adverse health outcomes including severe mobility limitation and mortality, and can be used within the short physical performance battery (SPPB) or individually (Cruz-Jentoft et al., 2018). Sarcopenia definitions eliminating physical function can potentially eliminate people at risk of a number of negative health outcomes (Sim et al., 2018). Given older populations are growing in the US, sarcopenia will continue to present a major healthcare problem. If FNIH is largely applied in the US, prevalence of sarcopenia appears lower than according to EWGSOP1. Consequently, public spending on sarcopenia may be reduced in the short term. However, since there would be large numbers of people undiagnosed, this could lead to greater long-term spending on the end-effects of sarcopenia (e.g., falls and fractures). Therefore, it is advisable to have a universally accepted definition to provide consistency and accuracy in identifying sarcopenia (Beaudart et al., 2015).

Upon diagnosis, appropriate interventions can be prescribed to address sarcopenia, leading to improved QoL and ability to perform ADL, such as dressing or climbing stairs. Increasing evidence demonstrates that therapeutic interventions can improve health and QoL outcomes for those with, or at risk of, sarcopenia (Waters, Baumgartner, Garry & Vellas, 2010). Exercise, particularly resistance training, has been proved to reduce the loss of muscle mass and strength (Fiatarone et al., 1990; Landi, Marzetti, Martone, Bernabei & Onder, 2014; Montero-Fernandez & Serra-Rexach, 2013; Moore et al., 2019; Vikberg et al., 2019), even in the very old (Fiatarone et al., 1990). Other strategies include nutritional supplements (e.g., vitamin D, creatine and protein) or anabolic hormones (e.g., testosterone, estrogen and growth hormone [GH] (Waters et al., 2010).

Most of the first-generation muscle drugs were developed to target loss of muscle mass, the initial characteristic of sarcopenia, however drug-induced hypertrophy is not sufficient as a treatment unless it also leads to improvements in muscle strength and physical function (Rooks & Roubenoff, 2019). Clinical trials have successfully demonstrated a number of measurable changes in muscle mass but less successfully in increasing muscle strength and function. Over the last 10 years, many approaches have been explored to counter age- and muscle-related loss of physical function, including expansion of current drugs registered to treat other conditions and development of biological pathways (molecules and biologics) (Rooks & Roubenoff, 2019). However, no drug has yet proved safe enough to be registered for muscle wasting or sarcopenia; many mechanisms are in phase II development for efficacy and dose range (e.g., activin receptor antagonist, myostatin or activin inhibitor, selective androgen receptor modulator [SARM]) (Rooks & Roubenoff, 2019).

A review of the neuromuscular alterations contributing to sarcopenia is beyond the scope of this literature review, as neuromuscular alterations are not a focus of this thesis and have been comprehensively reviewed recently (Larsson et al., 2018). Overall, sarcopenia as a muscle disease and geriatric symptom presents a serious health and public concern in older adults if they are at risk or not treated.

2.3 Health-related quality of life

A growing prevalence of older adults is a global issue and maintaining a good HRQoL is a high priority for the ageing population (Yen & Lin, 2018). HRQoL is a subjective metric covering three broad dimensions: physical/occupational function, social health/integration and mental health/psychological state. Conversely, non-health-related QoL comprises financial, economic, spiritual, political or environmental aspects (Rizzoli et al., 2013). HRQoL is also referred to as patient-reported outcomes, as the health report comes from the patient without consultation with practitioners or others (Rizzoli et al., 2013). Self-reported questionnaires can assess differences in HRQoL between people at a point in time (discriminative instruments) or longitudinal changes in HRQoL within people over time (evaluative instruments). HRQoL instruments can help policymakers and healthcare providers understand people's needs, particularly those of older adults suffering from chronic diseases or sarcopenia, and implement policies and reforms accordingly (Beaudart et al., 2018; Guyatt, Feeny & Patrick, 1993; Rizzoli et al., 2013).

More older American adults perceived their health as fair or poor and reported more physically unhealthy days compared to younger age groups in 2006–2010. However, older adults reported better health in 2010 compared to 2006 (Zack, 2013). Risky health behaviours (e.g.,

smoking cigarettes) can reduce HRQoL, negatively affecting health, but protective behaviours (e.g., physical activity) can improve HRQoL. Therefore, interventions to avoid risky behaviour and promote protective behaviour may contribute to increased HRQoL (Zack, 2013). Poor HRQoL is associated with chronic diseases (Eton et al., 2019; Juenger et al., 2002), depression (Ghimire et al., 2018), disability risk (Groessl et al., 2007, 2019) and mortality in older adults (Brown, Thompson, Zack, Arnold & Barile, 2015; Giles, Hawthorne & Crotty, 2009; Lindström et al., 2019). HRQoL is significantly poorer in older adults with heart failure than it is in healthy older adults, with physical symptom status being the greatest predictor of HRQoL in both groups (Heo, Moser, Lennie, Zambroski & Chung, 2007). Heo et al. (2007) asserted that age and anxiety are also associated with HRQoL in older adults with heart failure.

In meeting the challenges of the growing ageing sector, a combination of health preventive services and engagement in physical activity can improve HRQoL in Mexican older adults (Gallegos-Carrillo et al., 2019). Physical activity is beneficial for HRQoL in clinical populations—for example, those with non-small cell lung cancer (Granger, McDonald, Berney, Chao & Denehy, 2011), hypertension (Tsai et al., 2004), stroke survivors (Chen & Rimmer, 2011) or cancer survivors (Mishra et al., 2012). However, it is also beneficial for healthy older adults (Acree et al., 2006; Xu et al., 2018). Although vigorous intensity training is recommended, as it leads to greater physiologic improvements including decreased resting minute ventilation and heart rate, not all older adults are able to perform at this level (American College of Sports Medicine, 2014). Light intensity training may be more suitable for older adults, and has also been shown to improve symptoms, HRQoL and ability to perform ADL (American College of Sports Medicine, 2014). A recent study showed that both strength training/continuous aerobic training and strength training/high intensity interval aerobic training increased HRQoL. The strength training/high intensity interval aerobic training group was most effective in improving HRQoL, while a non-exercise group did not show any change after 12 weeks of training in middle-aged and older adults with diagnosed cardiovascular risk (Da Silva et al., 2019). In addition, a healthy diet is associated with higher HRQoL in US and Australian older adults, with higher scores indicating higher compliance according to the relevant national dietary guidelines (Milte, Thorpe, Crawford, Ball & McNaughton, 2015; Xu et al., 2018). The US cohort was assessed on an overall diet quality score based on 13 components (fatty acids, sodium, saturated fats, total vegetables, greens and beans, total fruit, whole fruit, whole grains, dairy, total protein foods, seafood and plant proteins, refined grains, and added sugars) using the Healthy Eating Index (HEI)-2015 (Xu et al., 2018). The Australian cohort used two different dietary guideline indices; the Recommended Food Score (RFS) and the

Mediterranean Diet Score (MDS), also based on 13 components (Milte, Thorpe, Crawford, Ball, & McNaughton, 2015). HRQoL is lower in subjects with sarcopenia than in those without sarcopenia (Beaudart et al., 2018; Go, Cha, Lee & Park, 2013; Verlaan et al., 2017).

In addition, HRQoL is related to life events, such as relocation into aged care. Hospitalised older adults awaiting residential aged care have a poor HRQoL (Giles et al., 2009). Over one-third of patients moving from hospitals into nursing homes for the first time reported their health state as worse than death (AQoL ≤ 0), which was a significant predictor of mortality. However, higher function was a predictor of higher HRQoL in the surviving population (Giles et al., 2009). A recent study indicated that older adults who continue or increase physical activity after relocation into long-term aged care have a positive HRQoL (Yen & Lin, 2018). Based on prior and current research, exercise and nutrition remain important to improve HRQoL in older adults.

2.4 Resistance training

Exercise has therapeutic benefits including improvements in morbidity, mortality and physical function in older adults (Bean, Vora & Frontera, 2004). Although aerobic training is commonly used in clinical programs, resistance training maintains and builds muscle mass, improves strength and endurance, minimises symptoms and increases QoL (American College of Sports Medicine, 2014). There is strong evidence that resistance training can prevent/reverse sarcopenia (Beaudart et al., 2016; Frost, Bronson, Cronin & Newton, 2016; Liu & Latham, 2009; Morley, 2018; Skelton, Young, Greig & Malbut, 1995; Taaffe, 2006; Tschopp, Sattelmayer & Hilfiker, 2011; Vikberg et al., 2019).

Resistance training can be performed using subjects' own body weight, standard weights or pneumatic equipment. Explosive resistance training can also be executed in hospitals and geriatric settings by using patients' own bodies (e.g., chair rise) as resistance if free weights or machines are not available (Cadore & Izquierdo, 2018). Progressive resistance training (PRT) is commonly used to improve muscle strength (Bean et al., 2004; Englund et al., 2019; Krist, Dimeo, & Keil, 2013). During PRT muscles are exercised against resistance produced by exercise equipment (e.g., exercise machines, free weights or elastic bands), which progressively increase as strength increases (Krist, Dimeo & Keil, 2013). PRT twice a week over eight weeks appears to improve mobility and muscle strength but not QoL, which may be due to a short intervention conducted on nursing home residents with limited mobility, aged 77–97 years in Berlin, Germany (Krist, Dimeo & Keil, 2013). The recent Position Statement from the National Strength and Conditioning Associations supports the benefits of resistance training in combating age-related sarcopenia, frailty, mobility limitations, chronic disease, disability and

premature mortality (Fragala et al., 2019). The Position Statement provides recommendations for healthy older adults (Part 1, see Table 2.1) and those with special considerations for frailty, sarcopenia or other chronic conditions (Part 4, see Table 2.2) (Fragala et al., 2019). Both recommendations incorporate a combination of resistance training, power and functional training, 2–3 times a week, 1–3 sets of 8–12 repetitions (Fragala et al., 2019).

Table 2.1:

Resistance training general recommendations for healthy older adults. †

Program variable	Recommendation †	Details
Sets	1–3 sets per exercise per muscle group	1 set for beginners and older adults with frailty progressing to multiple sets (2–3) per exercise.
Repetitions	8–12 or 10–15	Perform 6–12 reps with variation for muscular strength for healthy older adults. Perform 10–15 repetitions at a lower relative resistance for beginners.
Intensity	70–85% of 1RM	Begin at a resistance that is tolerated and progress to 70–85% of 1RM using periodisation. Lighter loads are recommended for beginners, or individuals with frailty, or special considerations such as cardiovascular disease and osteoporosis. Exercises should be performed in a repetition-range intensity zone that avoids going to failure to reduce joint stress.
Exercise selection	8–10 different exercises	Include major muscle groups targeted through multijoint movements (e.g., chest press, shoulder press, triceps extension, biceps curl, pull- down, row, lower-back extension, abdominal crunch/curl-up, quadriceps extension or leg press, leg curls, and calf raise).
Modality	Free-weight or machine-based exercises	Beginners, frail older adults, or those with functional limitations benefit from machine-based resistance training (selectorised weight or pneumatic resistance equipment), training with resistance bands, and isometric training. High functioning older adults gain added benefit from free-weight resistance training (e.g., barbells, dumbbells, kettlebells, and medicine balls).
Frequency	2–3 days per week, per muscle group	Perform on 2–3 non-consecutive days per week, per muscle group, may allow favourable adaptation, improvement, or maintenance.
Power/explosive training	40–60% of 1RM	Include power/explosive exercises where high-velocity movements are performed during the concentric phase at moderate intensities (i.e., 40–60% of 1RM) to promote muscular power, strength, size, and functional tasks.
Functional movements	Exercises to mimic tasks of daily living	Healthy, high functioning older adults benefit from the inclusion of multijoint, complex, and dynamic movements, with base of support or body position variations.

Adapted from Fragala et al. (2019, p. 2037). RM: repetition maximum. †General guidelines are provided. Resistance training programs should include variation in intensity and program variables. Strength exercises should be performed before endurance training during concurrent training sessions to optimize strength gains.

In addition, individuals from the Part 4 group are recommended to perform endurance and balance training (Fragala et al., 2019). Although low-intensity, low-volume programs are suitable for this group at the beginner level, progression to moderate to higher intensity programs (i.e., 40–60% of 1RM) is most beneficial to elicit functional improvements (Fragala et al., 2019).

Table 2.2:

Resistance training guidelines for older adults with frailty †

Condition	Modification
Frailty	Start at a lower resistance, progress more slowly, limit end point to volitional fatigue (start at 8–12 reps at 20–30% of 1RM and progress to 80% of 1RM).
Mobility limitations	Consider exercises in seated position.
Mild cognitive impairment	Select simple exercises. May require extra instruction and demonstration.
Diabetes	Monitor blood glucose before and after training. Consider special considerations of associated cardiovascular disease, nerve disease, kidney disease, eye disease, and orthopaedic limitations.
Osteoporosis	Begin at a lower intensity. Train balance, but exert extra care to prevent falls. Focus on form and technique and use caution with bending and twisting. Include postural exercises (spinal extension).
Joint pain or limited range of motion (arthritis)	Double-pinned machines may restrict ROM for joint pain, discomfort, and/or limited ROM. To allow for training through the pain-free part of the ROM and attain a training effect.
Poor vision, equilibrium and balance (falling), low-back pain, and dropping weights	Consider weight machines (as opposed to free weights).

Adapted from Fragala et al. (2019, p. 2037). ROM: range of motion; RM: repetition maximum

Supervised functional resistance training using functional exercises and suspension bands for 10 weeks preserves functional strength and improves muscle mass in Swedish older adults with pre-sarcopenia according to EWGSOP (Vikberg et al., 2019). Both models of resistance training using rubber bands/bottled water and pneumatic Keiser equipment elicited improvements in muscle strength and functional performance in Taiwanese community-dwelling older adults with a high risk of fractures after three months, with the first model being more cost-effective and easily replicable in community settings (Chan et al., 2018). Both free weights and

pneumatic training (via cable) improved maximal strength, velocity and power of Canadians who were experienced in resistance training. However, pneumatic training may have contributed to reaching unique force, velocity and power adaptations during exercises with the lowest relative loads (Frost et al., 2016). Another eight-week study, but on tennis players in Thailand, showed that a combination of free weight and pneumatic resistance training (via cable) is more effective than free weight training alone, as it increases power endurance, peak power and capacity to avoid lower velocity at the end of a longer sprint for tennis players (Apanukul, Suwannathada & Intiraporn, 2015). PRT using pneumatic Keiser equipment at moderate intensity effectively reduces plasma and tissue-specific inflammation after 16 weeks of intervention, which is associated with lowered fatigue and enhanced physical and behavioural function in US postmenopausal breast cancer survivors (Serra, Ryan, Ortmeyer, Addison & Goldberg, 2018).

HUR is another example of pneumatic resistance training. HUR was established in 1989 following a research project undertaken at the University of Technology in Helsinki (Helsinki University Research Australia, 2018a). Thanks to HUR's natural transmission method using pneumatic (air resistance) technology, resistance is adjusted according to the generation of force, irrespective of velocity of movement (Helsinki University Research Australia, 2018b). While many machines have a minimum resistance at a few kilograms and resistance is increased in 2.5 kg increments, HUR machines' minimum resistance begins at 0 kg and has stepless resistance adjustment with 100 g/1 kg increments (Helsinki University Research Australia, 2018a, 2018b). HUR gym features include individualised programs designed by trained staff (physiotherapists/exercise physiologists) and computerised smart card and smart touch systems that record clients' visits and work-outs (Helsinki Program, 2018; Helsinki University Research Australia, 2018b). During the workout, the smart card automatically adjusts resistance. The touchscreen displays repetitions, load, seat and lever arm position, and monitors heart rate. The system also provides instructions, goals and feedback on progress. This gives an immediate sense of achievement and maintains participants' motivation. Performance monitoring reports are provided, and programs updated automatically (Helsinki University Research Finland, 2018c).

In addition, HUR equipment includes range limiters and extra support, suitable for users of all abilities, enabling early rehabilitation (Helsinki University Research Finland, 2018b). Recent research showed that the Sunbeam program, including moderate-intensity PRT using HUR equipment and high-level balance exercises using chair or table, significantly decreased falls by 55% and enhanced physical performance of Australians living in long-term aged-care facilities (Hewitt et al., 2014, 2018). The supervised intervention involved 1–2 sessions a week at one hour per session for 50 hours over 25 weeks (Hewitt, Goodall, Clemson, Henwood, &

Refshauge, 2018). The PRT intensity was 2–3 sets of 10–15 repetitions, targeting mainly lower limbs, one each for the upper limbs and trunk. This was followed by a 6-month maintenance period (Hewitt et al., 2018). Given HUR equipment has successfully contributed to a reduction of falls in older populations in aged care, it can be used in the context of sarcopenia in both community-dwelling and residential older adults. While pneumatic machines are tailored for high-velocity power training and commonly used by researchers, they may be less accessible due to high costs and the required supporting equipment than conventional plate-loaded machines that are not designed for power training (Balachandran et al., 2017). Both pneumatic and plate-loaded machines are safe and effective in increasing lower-body power and physical function in older adults (Balachandran et al., 2017).

Strength and power training are varieties of resistance training. Strength is force produced during or while attempting a movement, and power is a product of the work (force x distance) executed per unit time (Metter, Conwit, Tobin & Fozard, 1997). In other words, strength is the ability to produce force, and power to produce force quickly. Rising slowly from a chair uses strength and is harder to perform than rising quickly from sitting using power (Norman, 2010). Power training, which uses moderate to high loads, consists of two phases—a fast concentric phase (muscle shortening) and a slower eccentric phase (muscle lengthening) (Balachandran et al., 2017)—and involves high-velocity contractions (i.e., contracting the muscles fast against resistance; Norman, 2010). Current training guidelines recommend high-velocity, low-load training, as it is associated with generating force quickly and improving the ability to perform ADL (Anthony & Brown, 2016).

Over the last two decades, researchers and professionals have been aware that strength training increases functional performance. Yet, although research continues to demonstrate that power training affects function more than strength training does, this knowledge has not been applied extensively in exercise protocols (Norman, 2010). An older adult will more likely move an object of low external resistance fast (involving velocity) than an object of high external resistance slowly (involving force) (Sayers & Gibson, 2014). Although force is important for physical function, the ability to move quickly—for instance, crossing a busy road or hitting breaks to avoid an accident—may be more relevant (Sayers & Gibson, 2014). Only high-speed power training changes the external resistance (through which power was generated) to a lower external resistance, enhancing the velocity component of peak power and ensuring safety in older adults (Sayers & Gibson, 2014). Even frail community-dwelling older adults can perform a 12-week program of structured functional power training incorporating high-velocity movement of upper and lower-extremity resistance exercises and low loads, implying that functional power

training is safe and feasible for those populations (Tan et al., 2018). Another advantage of power training is that it sustains lower values of blood pressure during subsequent activities that mimic ADL, at least in older women (Coelho-Júnior et al., 2017). Lower-extremity power training improves gait speed in older adults by generating ankle joint power without increasing power from hip and knee joints (Uematsu et al., 2018). Although strength training is effective for retaining and increasing muscle mass, power training can prevent age-related loss of muscle mass and strength (Wallerstein et al., 2012), improving QoL (Katula, Rejeski & Marsh, 2008).

Considerable research shows that muscle power is a greater predictor of physical function than of muscle strength in older adults (Bean et al., 2003; Hruda, Hicks & McCartney, 2003; Marsh, Miller, Rejeski, Hutton & Kritchevsky, 2009; Miszko et al., 2003; Reid & Fielding, 2012; Rice & Keogh, 2009) and muscle power declines faster than muscle strength (Bean et al., 2003; Izquierdo, Aguado, Gonzalez, Lopez & Häkkinen, 1999; Skelton et al., 1994; Skelton et al., 1995; Suetta et al., 2019). A recent Dutch study indicated that while power-based measures (leg extension press and 30-second sit-to-stand tests) began to decrease at ages over 50 years, less power-based measures (handgrip strength and habitual gait speed) and lean mass (trunk lean mass [TLM], appendicular lean mass [ALM] and ALM/height^2 [ALM/h^2]) were unchanged until after the age of 70 years (Suetta et al., 2019). The faster decline in muscle power than strength can be due to age-associated changes in fibre-type composition, with increasing prevalence of the slower type I and decreasing proportions of the powerful type II fibres, particularly IIX (Mannion et al., 2000; Marsh et al., 2009). It can also be attributed to a decline in motoneurons, which are not easily regenerated (Larsson et al., 2018). Low-dose hip abductor-adductor power training for eight weeks appears to be more effective than strength training at improving maximal neuromuscular performance, weight transfer control and medio-lateral balance recovery in older adults (Inacio, Creath, & Rogers, 2018).

While programs to improve strength or use strength training protocols increased power, resistance training programs tailored to increase power may be more effective at enhancing power and reducing disability (Porter, 2006). Since older adults require sufficient lower limb speed to safely perform functional movements, for instance, crossing a busy intersection, high-speed power training is recommended to increase power at lower external resistances (Sayers, Gibson & Mann, 2016). Although high-velocity resistance training increases strength similarly to traditional low-velocity resistance training, it improves peak power more (Fielding et al., 2002). High-velocity resistance training is more effective to improve muscle power and higher-velocity lower intensity is more effective to improve physical function than it is traditional slow velocity training (Reid & Fielding, 2012). Octogenarian women (80–89 years) can perform

explosive-type heavy-resistance training (75–80% of the one repetition maximum; 1RM), leading to greater neuromuscular performance (Caserotti, Aagaard, Buttrup Larsen & Puggaard, 2008). This indicates that they can rapidly develop muscle force and may reduce fall risk more than those who have not trained (Caserotti et al., 2008). Even nonagenarians showed significant increases in lower-extremity muscle strength, ranging from 61–374%, muscle mass, and mobility following high-velocity resistance training over eight weeks (Fiatarone et al., 1990). In league with the current scientific evidence, explosive resistance training (at least combined with the traditional resistance training) has to be prescribed in healthy and frail older adults since it optimises functional capability gains, minimises risks of falls, increases muscle strength and power output, and stimulates muscle hypertrophy (Cadore & Izquierdo, 2018).

A systematic review and meta-analysis reported that supervised balance and/or resistance training enhances balance and muscle strength/power more than unsupervised programs in older adults (Andre Lacroix, Hortobagyi, Beurskens, & Granacher, 2017). A combined balance/strength training for 12 weeks increases balance and lower extremity muscle power, and the gains are preserved following detraining in community-dwelling older adults (André Lacroix et al., 2016). A supervised group significantly improved in Romberg test, stride velocity, TUG and chair stand tests, compared to an unsupervised group, implying that supervised training is more effective than unsupervised training, and thus training at least three times a week, with at least two sessions supervised by trained staff, is recommended to improve balance and muscle strength/power (André Lacroix et al., 2016).

Given numerous benefits of resistance training, including prevention/reversion of sarcopenia, particularly under supervision, and different modality types (free weights or machine-based exercises) for older adults, this project presents an opportunity to assess supervised resistance training using pneumatic HUR gym equipment and conventional equipment in the Melbourne study, and strength and power training in the El Paso study.

2.5 Nutrition

2.5.1 Protein requirements

Sarcopenia risk increases with chronic disease, poor diet and inactivity (Victoria State Government, 2014). The benefits of nutrition have been reported alone or in conjunction with resistance training (Beaudart et al., 2016; Jäger et al., 2017). The International Society of Sports Nutrition's position on protein intake is:

(1) An acute exercise stimulus, particularly resistance exercise, and protein ingestion both stimulate muscle protein synthesis (MPS) and are synergistic when protein

consumption occurs before or after resistance exercise; (2) For building muscle mass and for maintaining muscle mass through a positive muscle protein balance, an overall daily protein intake in the range of 1.4–2.0 g protein/kg body weight/day (g/kg/d) is sufficient for most exercising individuals, a value that falls within the Acceptable Macronutrient Distribution Range published by the Institute of Medicine for protein, and (3) There is novel evidence that suggests higher protein intakes (>3.0 g/kg/d) may have positive effects on body composition in resistance-trained individuals (i.e., promote loss of fat mass). (Jäger et al., 2017)

A systematic review reported that protein supplementation with resistance training may prevent more loss of muscle mass and leg strength than protein supplementation alone in older adults with a body mass index (BMI) ≥ 30 and BMI < 30 (Liao et al., 2017). According to a more recent systematic review to optimise muscle protein intake with resistance training, daily protein intake should be 1.6/g/kg/day and a maximum of 2.2 g/kg/d, which can be achieved by consuming three meals per day, each including ~0.53 g/kg/d protein or four meals of ~ 0.4g/kg/d protein (Stokes, Hector, Morton, McGlory & Phillips, 2018). The recommended dietary allowance (RDA) for adults is 0.8 g/kg of body weight per day (Campbell, Trappe, Wolfe & Evans, 2001; Chernoff, 2004; National Research Council, 1989). Generally, protein tissue comprises 30% of whole-body protein turnover. However, the ratio reduces to 20% or below at the age of 70; therefore, older adults require more protein/kg body weight than younger adults (Chernoff, 2004). While consumption of a diet providing the current RDA (0.8g/kg/d) led to a loss of ALM and grip strength, 2RDA for protein (1.6g/kg/d) enhanced whole-body lean mass and leg power with no change to ALM or thigh muscle cross-sectional area in older men (Mitchell et al., 2017).

According to the World Health Organisation (WHO), a healthy diet includes fruits, vegetables, legumes, nuts and whole grain, which contributes to preventing malnutrition and diet-related noncommunicable diseases (e.g., diabetes, heart disease, stroke, cancer). However, the growing consumption of processed food and urbanisation resulted in people eating more foods high in fats, energy and free sugars or salt/sodium and not many reach for healthy practices (World Health Organization, 2019). Figure 2.2 illustrates a healthy diet for adults.

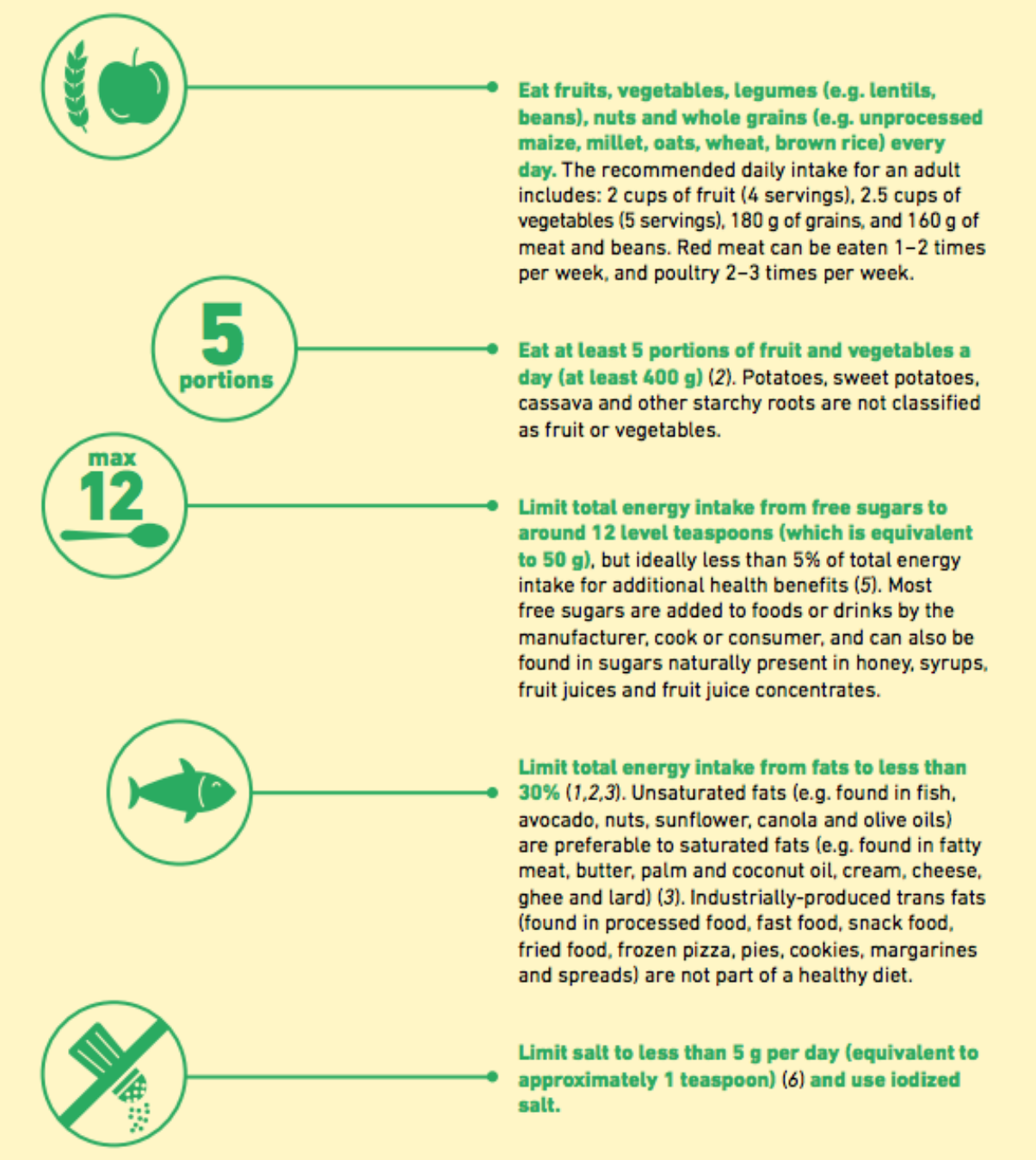

Figure 2.2. Healthy diet for adults

Reprinted from World Health Organization (2019, p. 11).

According to Australian dietary guidelines, a healthy balanced diet should include various foods from five core food groups and restricted intake of foods and drinks high in saturated fat, sugar and salt (Nutrition Australia, 2019). Table 2.3 presents the recommended daily intake for adults and older adults in Australia. While intake of vegetables and legumes for women remains at five serves a day, it slightly increases for men 19+ years. Fruit intake of two daily serves remains the same across gender for 19+ years. Intake of grains varies within gender and reduces with age

to three and four-and-a-half for older women and men, respectively. The intake of lean meat, fish, poultry and so on, increases with age for women up to two-and-a-half serves a day, but reduces to two-and-a-half for men aged 51+ years. The fifth group, including intake of milk, yoghurt, cheese and alternatives, increases for women 19–50 years and remains at four serves a day at 50+ years.

Table 2.3:

Recommended Daily Intake for Adults and Older Adults

			Vegetables and legumes	Fruit	Grains (cereal)	Lean meat, fish, poultry, eggs, nuts, seeds, legumes, beans	Milk, yoghurt, cheese & alternatives	Allowance for additional serves from any food group
Adults	Women	19–50 yrs	5	2	6	2.5	2.5	0–2.5
	Women	51–50 yrs	5	2	4	2	4	0–2.5
	Men	19–50 yrs	6	2	6	3	2.5	0–3
	Men	51–50 yrs	5.5	2	6	2.5	2.5	0–2.5
Older adults	Women	70+ yrs	5	2	3	2	4	0–2.5
	Men	70+ yrs	5	2	4.5	2.5	3.5	0–2.5

Adapted from Nutrition Australia (2019).

Knowledge about nutrition predicts adherence to healthy and unhealthy diet patterns (Taylor, Sullivan, Ellerbeck, Gajewski, & Gibbs, 2019). While adults with limited knowledge eat more food linked to the Western diet (red meat, processed and fried food, sugar-sweetened drinks), adults with good nutrition literacy are linked to prudent and Mediterranean diets (vegetables, nuts, olive oil) (Taylor et al., 2019). Healthy dietary patterns improve muscle health and ageing (Granic et al., 2019; Lee & Lee, 2019). Older Korean men with the healthy dietary pattern (fruits, vegetables, fish, potatoes, seaweeds, legumes, whole grains, mushrooms, eggs, dairy and red meat) have higher ALM than those with the unhealthy dietary pattern (Lee & Lee, 2019). Healthy dietary patterns, which are associated with improved physical function, were examined in community-dwelling octogenarians using the EWGSOP1 definition (Granic et al., 2019). Following three years, a group with a traditional British diet (red meat, gravy, potatoes, vegetables and sweets/desserts) that had the highest intake of fat and total energy, were associated with a 2.4-fold increased risk of sarcopenia, despite good protein intake, as opposed to the group with a diet high in unsaturated fat spreads/oils, fibre, which had the highest intake of protein and starch (Granic et al., 2019). A healthy dietary pattern (vegetables, fruit, fish) can also improve mental health as it is correlated with lower

levels of depressive symptoms among Australian women (but not men), whereas unhealthy dietary pattern (red and processed meat, hot chips, deserts, cakes and ice cream) is correlated with higher levels of depressive symptoms also in women (but not men) (Hart, Milte, Torres, Thorpe, & McNaughton, 2019). Further, healthy dietary patterns are associated with reduced risk of all-cause, cardiovascular disease and cancer mortality in US older adults (Reedy et al., 2014).

A meta-analysis reported that muscle increase was observed with protein intakes of up 1.6 g/kg/d, which is about twice the recommended guidelines according to most agencies. However, the daily protein intake beyond that level does not seem to contribute to increased muscle using resistance training (Morton et al., 2018). Protein supplements help improve muscle mass and strength, but this has a small effect (0.5kg and 9% respectively; Morton et al., 2018). Morton et al. (2018) also found that protein supplementation works better in people who have done resistance training for some time and can help people > 60 years, but not much. Following resistance training in untrained older women, protein intake of > 1.0 g/kg/d contributes to increased muscle mass and strength (Nabuco et al., 2019). Regardless of recommendations, about 40% of community-dwelling older adults fail to meet the RDA for total protein due to poor appetite, masticating, physical and mental disabilities that restrict shopping and food preparation as well as food insecurity for socioeconomic reasons (Deutz et al., 2014; Houston et al., 2008).

The key anabolic element of protein is the amino acid leucine, which has been shown to improve muscle protein synthesis (MPS) due to stimulation of the mammalian target of rapamycin (mTOR) (Anthony, Anthony, Kimball, & Jefferson, 2001; Devries et al., 2018). There are two types of sources for protein intake: animal-based (e.g., meat, fish, whey, poultry, eggs or milk) and plant-based (e.g., rice, soy, wheat, legumes, beans, or nuts). Animal-based proteins are usually higher in lysine, leucine, and methionine than plant-based sources, which means that greater amounts of plant-based protein are required to similarly increase muscle hypertrophy as opposed to animal-based proteins (Figure 2.3) (Hackney, Trautman, Johnson, Mcgrath, & Stastny, 2019).

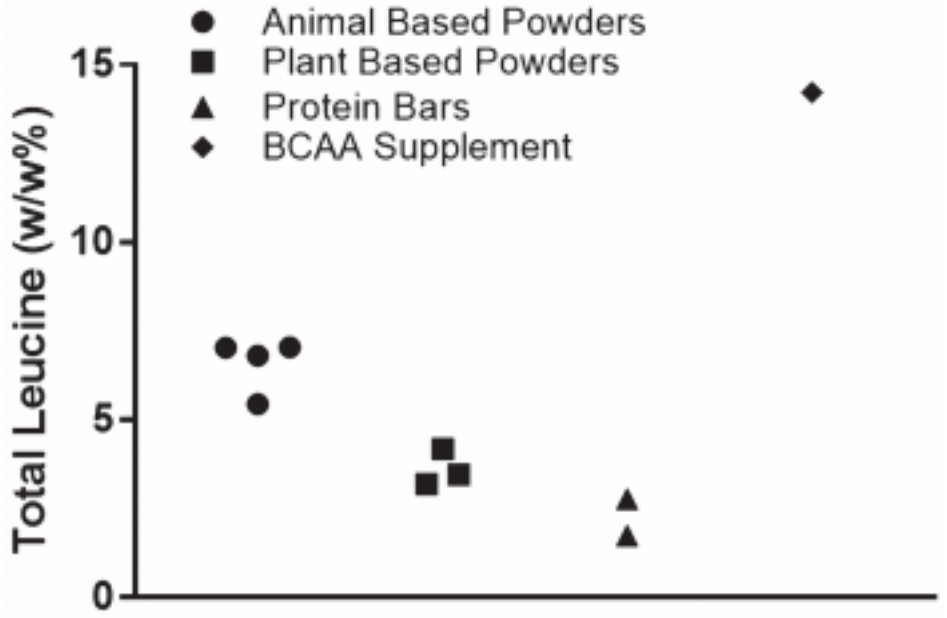

Figure 2.3. Leucine content evaluated in various protein sources relative to weight (w).

Reprinted from Hackney et al. (2019). BCAA: Branched-Chain Amino Acids.

Lean beef is important for older adults as it is a great source of nutrients (Hackney et al., 2019). Hackney et al. (2019) reported that while a 3-ounce portion of lean beef, together with six cups of cooked brown rice and one scoop of whey protein, provide around 2.15g of leucine, ½ cup of almonds or soybeans contributes to only about 0.4g of leucine. Also, a 3-ounce serving of lean beef contributes to approximately 10% of recommended daily calories, iron, riboflavin, 37% of vitamin B12, 33% of zinc and 25% of niacin and other nutrients (Hackney et al., 2019). When weighing risks, consumption of higher amounts of animal-based protein is less risky than smoking, alcohol or white bread consumption (15 slices or more per week) (Hackney et al., 2019; Sanjoaquin, Appleby, Thorogood, Mann, & Key, 2004).

Protein intake has pro-anabolic effects on skeletal muscle function that is mediated by gut microbiota (Liao et al., 2019; Ni Lochlainn, Bowyer & Steves, 2018; Ticinesi et al., 2019). Liao et al. (2019) argued that skeletal muscle and sarcopenia are affected by gut microbiota, which are affected by whey protein and resistance training (see Figure 2.4). While whey protein intake alone or in combination with resistance training can be used to prevent and treat sarcopenia, sex hormones could be potential contributors for differences between men and women in skeletal muscle and sarcopenia (Liao et al., 2019).

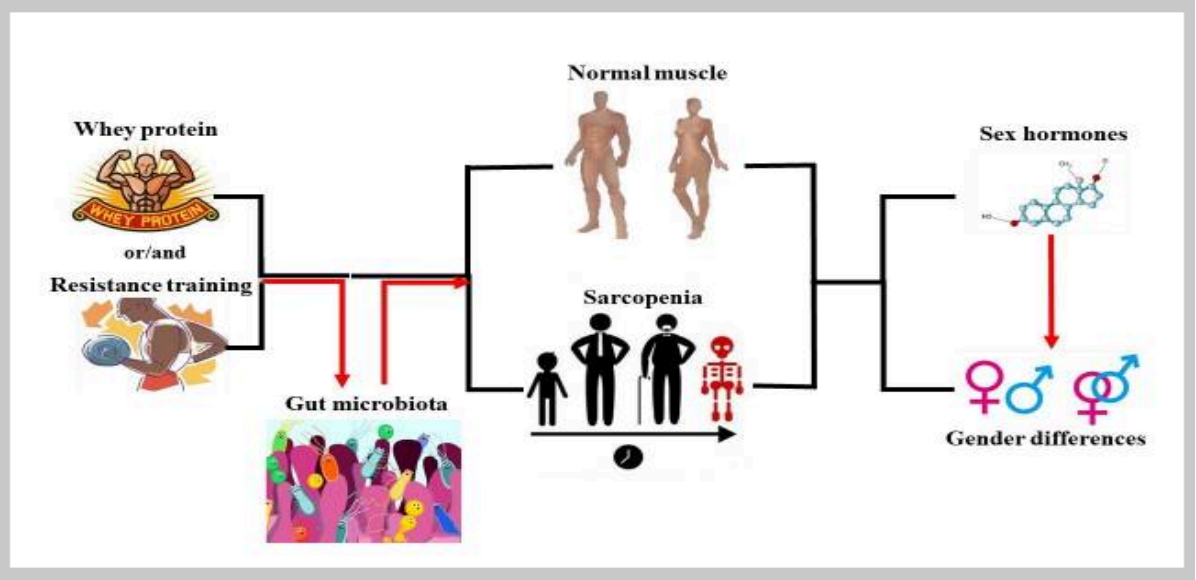

Figure 2.4. Whey protein and/or resistance training against age-related sarcopenia. Reprinted from Liao et al. (2019, p. 164).

Another systematic review confirmed that dairy protein can be a nutritional intervention to increase appendicular muscle mass in middle-aged and older adults (Hanach et al., 2019).

2.5.2 Energy requirements

While nutrient requirements either remain the same or increase with age, energy requirements decline due to lower physical activity levels, reduced metabolic rates and greater proportions of fat to lean muscle mass, emphasising the need for nutritional foods in each food category. In particular, resistance training is effective in enhancing energy requirements in older adults (Campbell, Crim, Young & Evans, 1994). While foods high in fat, added sugar and alcohol are the highest in kilojoules (kJ), fruit, vegetables and legumes are lower in kJ (Victorian State Government, 2018). Table 2.4 depicts energy needs according to predicted basal metabolic rate (BMR) and physical activity level (PAL) as recommended by the National Research and Medical Council in Australia (2017). For example, energy requirements for a 76 kg man, aged 51–70 years, range from 9.5 MJ (9,500 kJ) (sedentary activity) to 12.1 MJ (12,100 kJ) (moderate activity) and for people 70+ years, from 7.4 MJ (7,400 kJ) to 13.6 MJ (13,600 kJ), respectively. For a 61 kg woman, energy requirements are lower than that of men (i.e., at 51–70 years, 7.6–9.6 MJ (7,600–9,600 kJ) and at 70+ years, 7.1–9.1 MJ (7,100–9,100 kJ) (National Health and Medical Research Council, 2006).

Table 2.4:

Estimated Energy Requirements of Adults Using Predicted BMR x PAL

Age yr	BMI = 22.0[a]		BMR MJ/day Men	Physical activity level (PAL)[b] MJ/day Men						BMR Mj/day Women	Physical activity level (PAL)[b] MJ/day Women					
	H (m)	W (kg)		1.2	1.4	1.6	1.8	2.0	2.2		1.2	1.4	1.6	1.8	2.0	2.2
19–30	1.5	49.5	-	-	-	-	-	-	-	5.2	6.1	7.1	8.2	9.2	10.2	11.2
	1.6	56.3	6.4	7.7	9.0	10.3	11.6	12.9	14.2	5.6	6.6	7.7	8.8	9.9	11.1	12.2
	1.7	63.6	6.9	8.3	9.7	11.0	12.4	13.8	15.2	6.0	7.2	8.4	9.6	10.8	12.0	13.2
	1.8	71.3	7.4	8.9	10.3	11.8	13.3	14.8	16.3	6.5	7.7	9.0	10.3	11.6	12.9	14.2
	1.9	79.4	7.9	9.5	11.1	12.6	14.2	15.8	17.4	7.0	8.4	9.7	11.1	12.5	13.9	15.3
	2.0	88.0	8.4	10.1	11.8	13.5	15.2	16.9	18.6	-	-	-	-	-	-	-
31–50	1.5	49.5	-	-	-	-	-	-	-	5.2	6.3	7.3	8.4	9.4	10.4	11.5
	1.6	56.3	6.4	7.6	8.9	10.2	11.4	12.7	14.0	5.5	6.5	7.6	8.7	9.8	10.9	12.0
	1.7	63.6	6.7	8.0	9.4	10.7	12.1	13.4	14.8	5.7	6.8	8.0	9.1	10.3	11.4	12.5
	1.8	71.3	7.1	8.5	9.9	11.3	12.7	14.2	15.6	6.0	7.2	8.3	9.5	10.7	11.9	13.1
	1.9	79.4	7.5	9.0	10.4	11.9	13.4	14.9	16.4	6.2	7.5	8.7	10.0	11.2	12.5	13.7
	2.0	88.0	7.9	9.5	11.0	12.6	14.2	15.8	17.3	-	-	-	-	-	-	-
51–70	1.5	49.5	-	-	-	-	-	-	-	4.9	6.0	6.9	7.9	8.9	9.8	10.9
	1.6	56.3	5.8	7.0	8.2	9.3	10.4	11.5	12.7	5.2	6.2	7.3	8.3	9.3	10.4	11.4
	1.7	63.6	6.1	7.3	8.6	9.8	11.1	12.3	13.6	5.4	6.5	7.6	8.7	9.8	10.7	12.0
	1.8	71.3	6.5	7.8	9.1	10.4	11.7	13.1	14.4	5.7	6.9	8.0	9.1	10.3	11.4	12.6
	1.9	79.4	6.9	8.3	9.6	11.1	12.4	13.8	15.2	6.0	7.2	8.4	9.6	10.8	12.0	13.2
	2.0	88.0	7.3	8.8	10.2	11.7	13.2	14.7	16.1	-	-	-	-	-	-	-
>70	1.5	49.5		-	-	-	-	-	-	4.6	5.6	6.5	7.4	8.3	9.3	10.2
	1.6	56.3	5.2	6.3	7.3	8.3	9.4	10.4	11.5	4.9	5.9	6.9	7.8	8.8	9.8	10.8
	1.7	63.6	5.6	6.7	7.8	8.9	10.0	11.2	12.3	5.2	6.2	7.2	8.3	9.3	10.3	11.4
	1.8	71.3	6.0	7.1	8.3	9.5	10.7	11.9	13.1	5.5	6.6	7.7	8.7	9.8	10.9	12.0
	1.9	79.4	6.4	7.6	8.9	10.2	11.4	12.7	14.0	5.8	6.9	8.1	9.2	10.4	11.5	12.7
	2.0	88.0	6.8	8.1	9.5	10.8	12.2	13.5	14.9	-	-	-	-	-	-	-

Adapted from National Health and Medical Research Council (2006, p. 20). BMR: basal metabolic rate; PAL: physical activity level. '[a] A BMI of 22.0 is approximately the midpoint of the World Health Organization (WHO) (1998) healthy weight range (BMI 18.5–24.9); [b] PAL ranges from 1.2 (bed rest) to 2.2 (very active or heavy occupational work). PALs of 1.75 and above are consistent with good health. PALs below 1.4 are incompatible with moving around freely or earning a living. PALs above 2.5 are difficult to maintain for long periods. The unit of energy is kilojoule (kJ) or megajoule (1 MJ = 1,000 kJ) and 4.18 kJ = 1 kilocalorie'.

Shortage of energy intake rather than protein intake is linked with sarcopenia (according to EWGSOP2) in older Japanese patients with type 2 diabetes (Okamura et al., 2019). One way to provide nutritional meals for older Australians can be 'meals on wheels', which meet guidelines for energy and protein, with 'standard meals' containing 21–39% for energy and 42–63% for protein and 'energy and protein fortified meals' containing 29–55% and 46–69% respectively (Arjuna et al., 2018).

Overall, adequate nutritional levels in conjunction with physical activity, especially resistance training, can counteract sarcopenia. With the growing population of older adults globally, including Australia and the US, improved knowledge regarding nutrition and diet should be a public health priority and gender difference should be taken into account for muscle health.

2.6 Hypotheses

This literature review demonstrated that physical activity, particularly resistance training and nutrition, are primary interventions to prevent/counteract sarcopenia. There are few studies using the revised EWGSOP2 and sarcopenia components in association with self-perceived function, physical activity, HRQoL and nutrition in older adults, to consider sarcopenia prevalence and risk. The Melbourne study, conducted in March–May 2019, presented an opportunity to explore sarcopenia risk factors in established gyms for seniors, both conventional and HUR gyms, which have proven effective in reducing falls rates in older Australians, but have not been investigated in relation to sarcopenia. The El Paso study, as part of the Golden Age program for community-dwelling older adults conducted in August and December 2016, will add to the value of the existing research regarding strength training and power training.

The research enquiry has promoted the development of hypotheses regarding prevalence of sarcopenia and associations of sarcopenia components with self-reported measures. The Melbourne study included self-reported function, physical activity, HRQoL and nutrition. Since the El Paso study was conducted before the introduction of EWGSOP2, a sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls (SARC-F; see Appendix A) was not commonly used in 2016. The Physical Activity Scale for the Elderly (PASE; see Appendix B) was only undertaken within Study 1. However, assessment of QoL (AQoL-4D; see Appendix C) was conducted identically in both studies. The AES (see Appendix D) was only part of the Melbourne study.

Study 1: Melbourne

H1: There is a significant difference between HUR and conventional gym training for sarcopenia prevalence and its components in older adults lightly and voluntary physically active.

H2: Components of sarcopenia are associated with poorer self-reported function in older adults participating in exercise programs lightly and voluntary physically active.

H3: Components of sarcopenia are associated with lower self-reported physical activity in older adults participating in exercise programs lightly and voluntary physically active.

H4: Components of sarcopenia are associated with poorer HRQoL in older adults participating in exercise programs lightly and voluntary physically active.

H5: Components of sarcopenia are associated with lower self-reported nutrition in older adults participating in exercise programs lightly and voluntary physically active.

Study 2: El Paso

H1: There is a significant difference between strength and power/agility training for sarcopenia prevalence and its components in older adults previously inactive and sedentary.

H2: Components of sarcopenia are associated with poorer HRQoL in older adults participating in exercise programs previously inactive and sedentary.

Chapter 3: Theoretical Framework

This project refers to the diagnosis of sarcopenia according to three definitions. The first European definition was presented by EWGSOP in 2010 (Cruz-Jentoft et al., 2010). In October 2018, EWGSOP proposed a revised operational criterion and algorithm (Cruz-Jentoft et al., 2018). These EWGSOP definitions are referred to here as EWGSOP1 and EWGSOP2. The third is an American definition from the FNIH sarcopenia project, which was launched in 2010. While Australia is likely to adopt EWGSOP1 (Zanker et al., 2019), it is important to assess the components of sarcopenia and their correlation with the European and American definitions, particularly given the involvement of the UTEP collaborators, as the FNIH definition will be adopted in the US. It is also worth exploring the changes between EWGSOP1 and EWGSOP2.

The sarcopenia cut-off points according to the different definitions are presented in Table 3.1. According to the FNIH definition, sarcopenia is measured by low strength (assessed by handgrip strength) and low lean mass (calculated as ALM/BMI) (Studenski et al., 2014) as shown in Figure 3.1. Both EWGSOP criteria are based on low muscle strength, low muscle/lean mass calculated as ALM/h^2 and low physical performance. According to EWGSOP1, sarcopenia can be detected in two ways: by low physical performance (assessed by low gait speed) and loss of muscle/lean mass, and/or by normal gait speed but low grip strength (assessed by handgrip strength) (Cruz-Jentoft et al., 2010) as presented in Figure 3.2. The 'presarcopenia stage' is identified by low muscle/lean mass; the 'sarcopenia' stage is detected by low muscle/lean mass and low muscle strength or low physical performance; and the 'severe sarcopenia' stage is specified when all three criteria are met, which are low muscle/lean mass, low muscle strength and low physical performance (Cruz-Jentoft et al., 2010).

The changes in criteria from EWGSOP1 to EWGOP2 were implemented because sarcopenia, as a muscle disease, can occur earlier in life. Muscle strength took the lead, as it is easier to assess and a better predictor of the adverse effects of sarcopenia than muscle mass (Cruz-Jentoft et al., 2018). EWGSOP2 recommends using the four-step pathway represented as Find-Assess-Confirm-Severity (F-A-C-S) as shown in Figure 3.3. The first step is to use SARC-F (see Appendix A), which is a cost-effective and convenient tool for sarcopenia risk screening to predict low muscle strength (Cruz-Jentoft et al., 2018; Malmstrom, Miller, Simonsick, Ferrucci & Morley, 2016; Morley & Malmstrom, 2014). If the result is negative, there is no sarcopenia risk and the subject should be rescreened later. However, if it is positive or there is clinical suspicion, muscle strength is assessed by grip strength or a chair stand.

Sarcopenia is probable in the presence of low muscle strength. A sarcopenia diagnosis is confirmed if there is also low muscle/lean mass. When low muscle strength, low lean muscle and low physical performance (assessed by gait speed, SPSS, timed up and go [TUG] or 400mW) are all detected, sarcopenia is regarded as severe (Cruz-Jentoft et al., 2018) (see Figure 3.2). For this thesis, regardless of the SARC-F results, the resultant physical function tests and DEXA were performed to directly compare sarcopenia prevalence with the different algorithms. The presence of various operational definitions with different cut-off points presents a barrier in the diagnosis of sarcopenia. The development of a universally accepted definition would lead to clearer diagnosis of sarcopenia.

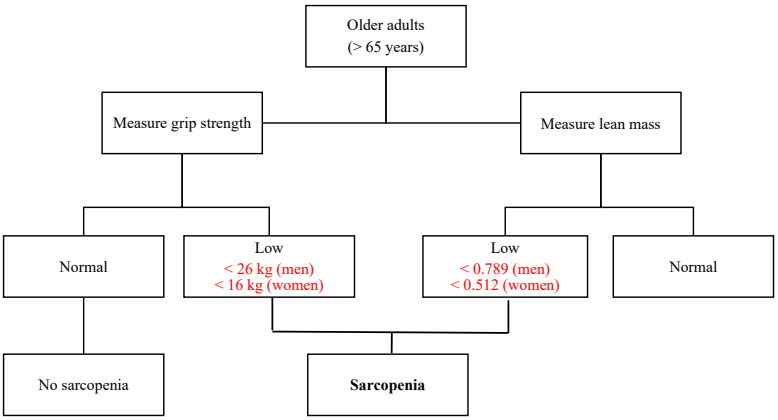

Figure 3.1. FNIH algorithm for sarcopenia case finding in older individuals.
Adapted from Studenski (2014). Presentation adapted from Cruz-Jentoft et al. (2010, p. 420).

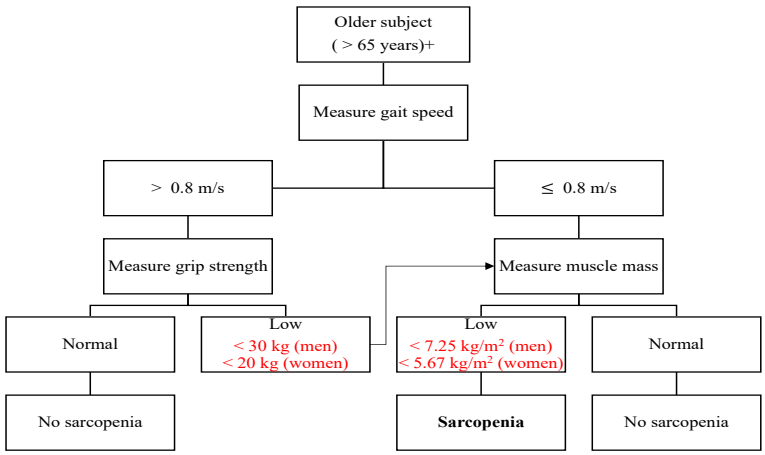

Figure 3.2. EWGSOP1 algorithm for sarcopenia case finding in older individuals.
Adapted from Cruz-Jentoft et al. (2010, p. 420). +This algorithm can also be applied to younger individuals at risk.

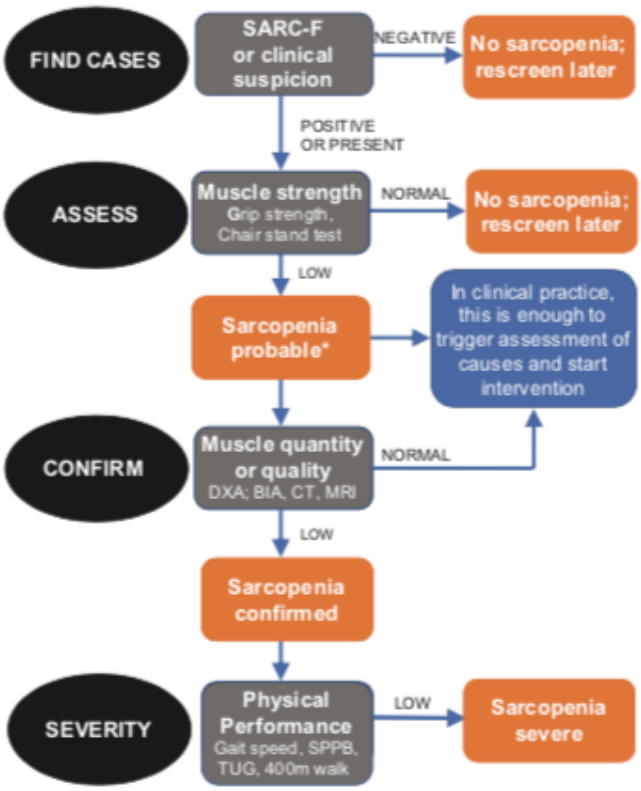

Figure 3.3. EWGSOP2 algorithm for sarcopenia case finding.

Reprinted from Cruz-Jentoft et al. (2018, p. 9).

Table 3.1*:*

Sarcopenia Cut-Off Points According to Different Definitions

Sarcopenia component	Measure	FNIH		EWGSOP1		EWGSOP2	
		Men	Women	Men	Women	Men	Women
Low lean mass	DEXA	ALM/BMI < 0.789	ALM/BMI < 0.512	ALM/h^2 < 7.25 kg/m^2	ALM/h^2 < 5.67 kg/m^2	ALM/h^2 < 7.0 kg/m^2	ALM/h^2 < 6.0 kg/m^2
Low strength	Chair stand (5 rises)	-	-	-	-	15 s	15 s
	Grip strength	< 26 kg	< 16 kg	< 30 kg	< 20 kg	< 27 kg	< 16 kg
Low performance	Gait speed	-	-	< 0.8 m/s		≤ 0.8 m/s	
	SPPB	-	-	≤ 8-point score		≤ 8-point score	
	TUG	-	-	-	-	≥ 20 s	
	400mW	-	-	-	-	Non-completion or ≥ 6 min for completion	

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; ALM: appendicular lean mass; BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400mW: 400-metre walk.

Chapter 4: Methods

4.1 Research design

The Melbourne study was the first phase (baseline) of a longitudinal design that used convenience sampling to observe participants who were undergoing exercise training under the supervision of exercise physiologists/physiotherapists. The initial study was designed to be one year in duration, with six-monthly and one-yearly follow-up data collections and analysis and continued data collection on a yearly basis. The purpose of this study was to explore sarcopenia and its components with self-reported HRQoL, function, physical activity and nutrition. Due to the time frame of a master's degree, only the baseline data has been collected and analysed and, as a result, is cross-sectional in nature. Post-data at six and 12 months will be collected and analysed beyond this time frame.

The Physical Fitness in the Golden Age program for community-dwelling older adults has been running for almost 10 years in El Paso, Texas, US. This study analysed historical data collected in 2016 before intervention (T1) and following a 16-week blocked randomised quasi-experimental design (T2) that was employed on two different interventions: ST and PT. The principal supervisor was involved in the design and data collection phase for this cohort of participants. The purpose of the analysis conducted in this thesis was to assess sarcopenia and its associations with self-reported function, physical activity, HRQoL and nutrition.

4.2 Participants

4.2.1 Sample size and recruitment of participants

The Melbourne study participants were older adults lightly and voluntary physically active in community settings. The study was conducted in Uniting AgeWell gyms. In April 2018, it was estimated that there were about 300 users of the Forest Hill HUR gym that has been operating for the past two years: 100 at the Oakleigh gym, which opened in August 2017, and 20 at the Noble Park gym, which started in November 2017 and has the newest HUR equipment. The conventional gym in Hawthorn had about three hundred clients. Only the gyms at Forest Hill and Noble Park were attached to aged-care facilities. Thus, the recruitment for this study came from a pool of approximately 720 existing gym members plus those willing to join the gyms during the study. Using lean mass as the primary end-point and data collected from the previous study conducted at UTEP in a similar age group, the highest variation in lean mass was mean +/– 20%, which, if looking for a 10% improvement, would require n = 67 with alpha 0.05 and beta 0.2 (i.e., 80% power) (Power and sample size, 2018). Most groups in the

UTEP study were closer to a mean of +/– 10%, in which case even a 5% improvement would require no more than the same participant number listed above. Using GPower v. 3.1 (Power and sample size, 2018), 34 gym clients were required to achieve an effect size of 0.5 (i.e., a moderate-to-large effect). It was planned to recruit as many Uniting AgeWell gym users as were willing to participate; however, given the above, and allowing for attrition of up to 20% over six months, a minimum of 80 participants would need to be recruited. As mass was the slowest measure to change, this number ensured the ability to identify training-based adaptations in physical function. Given that there were more than 300 current clients across the various locations, a sufficient number of participants could be obtained to establish a moderate effect of training on body composition. To achieve an overall target of 80 participants, roughly 20 participants per gym were required.

The recruitment strategies included displaying posters (see Appendix E) in the respective gyms. Between February and March 2019, 114 subjects were recruited from the four participating gyms. The Forest Hill and Hawthorn gyms exceeded their targets (see Figure 4.1), reporting an overall success of 143%. All participants that were available for testing were included to maintain the power for the study, thus no specific adherence criteria were required.

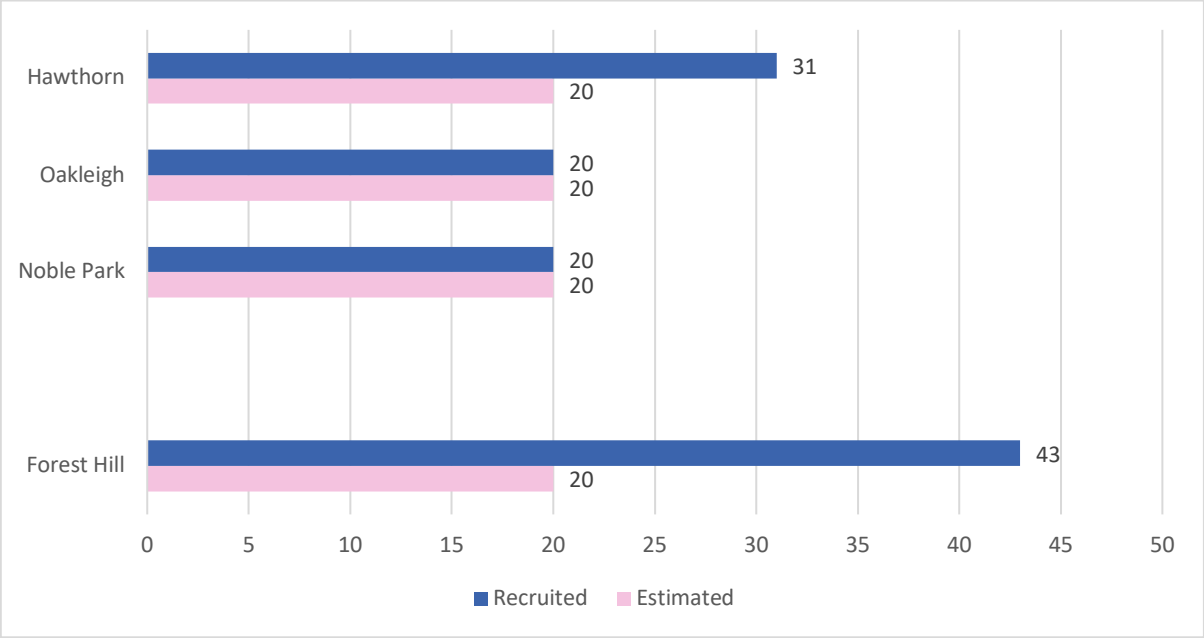

Figure 4.1. Estimated v. actual recruitment, Melbourne.

The baseline data were collected in March–May 2019. During the study, nine participants discontinued from the HUR group but none from the conventional gym, leaving 105 to analyse. The study profile is presented in Figure 4.2.

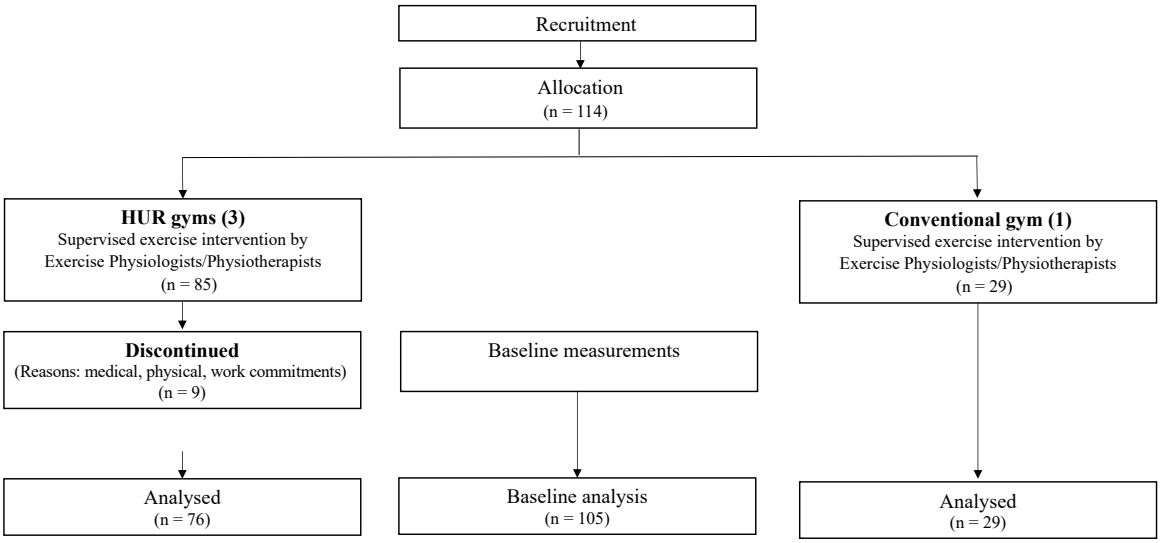

Figure 4.2. Study profile, Melbourne.

Discontinuation reasons included work commitments and personal and medical reasons (see Table 4.1).

Table 4.1:

Discontinuation Reasons, Melbourne

Gym	Men	Women	Reason
Forest Hill	-	1	New to gym; cannot commit to research (work/distance to gym)
Noble Park	1	-	Limited carer's availability to bring client for assessments
	2	-	Medical/physical condition
		1	Personal reasons
	-	2	New recruits to the gym (mother and her daughter carer); daughter's full-time work commitment
Oakleigh	-	1	Work commitment
	-	1	Had a fall (outside of gym/research)
Total	3	6	

The El Paso cohort included physically inactive and sedentary community-dwelling older adults in laboratory settings. The El Paso study was part of the Physical Fitness in the Golden Age program, which is an ongoing study among community-dwelling older adults in the El Paso region. It was anticipated to obtain a sample of 100 adults aged 60 or older, both

male and female, without any particular gender ratio. The 100 subjects were to constitute two even-sized groups of 50 subjects, with one group undertaking ST and the other undertaking PT. This number included over-recruitment by approximately 40% to account for subject attrition. Previous studies from the UTEP laboratory saw 33% attrition over a 52-week intervention period; thus, an expected maximum 25% attrition rate was reasonable for the proposed 16-week intervention. The adequacy of the sample size for the planned analyses was assessed with a power analysis, counting for both potentially equal and unequal intervention and comparison group sample sizes. The power analysis was based on the assumption that there would be a moderately large effect size (i.e., 0.7) between groups. This assumption was based on previous studies in the UTEP laboratory, in which effect sizes between experimental and non-exercising control subjects were large (effect size = 0.9) for most fitness measures. If counting with equal sample sizes, for a one-tailed two-sample t-test with a moderately large effect size of 0.70 and 80% power with alpha 0.05, a total sample size of 52 subjects was calculated. If calculating with unequal sample sizes in the two groups, for a one-tailed two-sample t-test with a moderately large effect size of 0.70 and 80% power with alpha 0.05, a total sample size of 60 subjects was required. The recruitment of 100 subjects (50 per group) was to ensure a high statistical power (> 80%) even after an unlikely 50% attrition in each group.

The recruitment strategies from the El Paso region included: (1) visiting target communities and senior centres; (2) contacting up to 300 older adults from a database who had previously enquired about involvement in physical activity programs; (3) using partnerships with physicians and doctors' practices and the local Area Agency on Ageing to distribute flyers and display posters; and (4) promoting through the local media. There were 135 participants recruited in the El Paso region, reporting an overall success rate of 135% (see Figure 4.3).

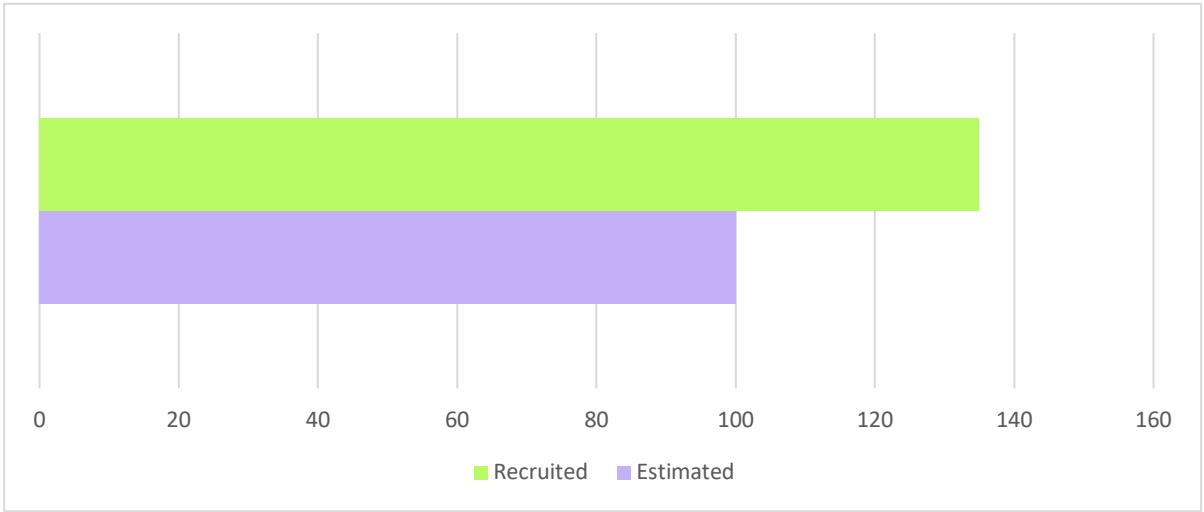

Figure 4.3. Estimated v. actual recruitment, El Paso.

The El Paso study profile is presented in Figure 4.4. The discontinuation rate of 31% due to dropouts and injuries was not explored.

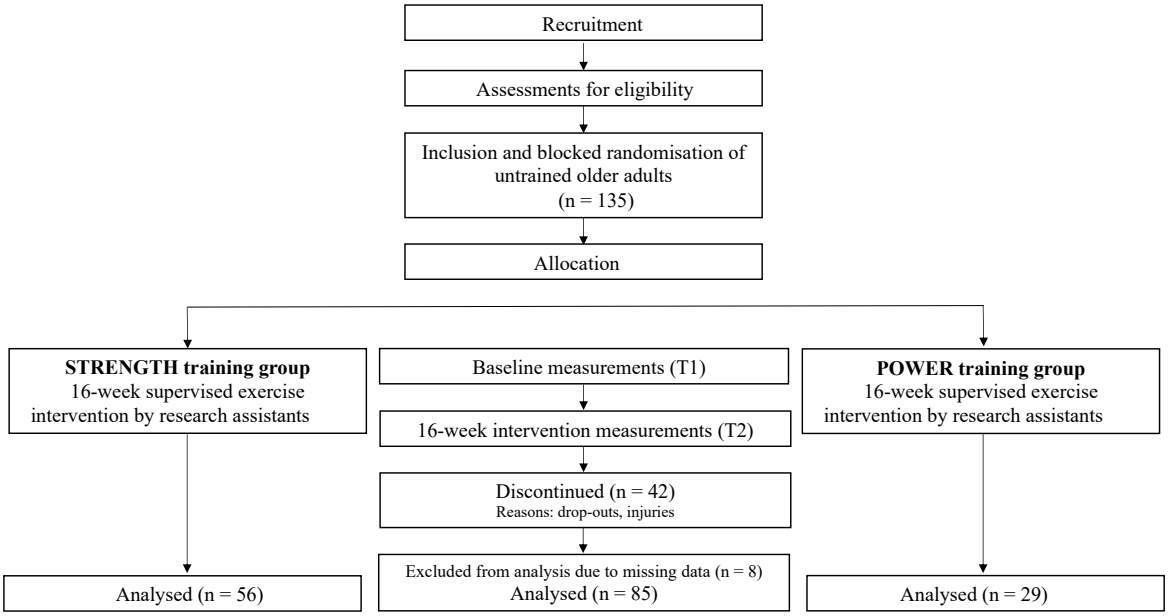

Figure 4.4. Study profile, El Paso.

4.2.2 Inclusion criteria

The Melbourne study inclusion criteria were that the subjects had to be Uniting AgeWell clients who were already gym members or had just joined the gym and were living at home or in Uniting AgeWell residential care. All gym clients who were accepted to take part in the exercise training (per Uniting AgeWell guidelines and screening) were eligible to participate, independent of type of training, frequency or duration. The majority of Uniting AgeWell clients were aged 65 years and over, especially if they were entitled to funded services. Anyone under that age would have to pay full fee. Thus, there would not be many clients aged 55–65 years enrolled in Uniting AgeWell gyms in Melbourne. Young people would usually use mainstream services, not services designed for seniors. Ethical approval for this project was obtained from the Victoria University Human Research Ethics Committee (Project Number: 25901) on 19 December 2018. Written consent was obtained from the Uniting AgeWell management via a 'Permission Letter' on 26 September 2018. Two program managers acted as gatekeepers who permitted access to the research site and subjects (Creswell, 2014). All participants signed a 'Research Participant Consent Form' (see Appendix F) and were informed about the purpose of this study via the 'Information to Participants Involved in Research' document (see Appendix G). It was also explained to participants that they could withdraw from the study at any time. The confidentiality and privacy of the participants were

protected by assigning study IDs and securely storing the data. To find out more about the project and participation requirements, clients could ask the therapists or administrative staff located at the gym or contact myself or the chief investigator listed on the posters. I also visited the participating gyms to assist with enquiries at set times over the period of a month. Clients could place their completed consent forms in locked boxes located at the gym reception desk at each site or mail it to the chief investigator in the prepaid envelopes provided. All participants except three were already undergoing standard exercise programs at the four Uniting AgeWell sites in Forest Hill, Noble Park, Oakleigh and Hawthorn. Two new recruits joined the HUR gyms and one joined the conventional gym at the beginning of this study. However, two of them discontinued and were excluded from the analysis. Thus, only one participant was new to the gyms. There were only two participants living in the residential care of the Uniting AgeWell.

In the El Paso study, one of the inclusion criteria was that the participants were undertaking no reported regular participation in physical activity, that is, less than 20 minutes of vigorous physical activity three days a week (less than 60 minutes of total exercise a week). Trained research assistants contacted applicants by phone and requested a personal meeting. During this meeting, details on the intervention were shared and a written informed consent was collected. The 135 participants who reported undertaking less than 60 minutes of vigorous exercise a week, the information on which was obtained via an exercise history survey and had gained a medical release/written approval from their healthcare provider indicating a level of physical health, were accepted to participate in the exercise program. The participants were randomly assigned into one of two groups: ST or PT. Considering the older adult population statistics in El Paso, the majority of the subjects was predicted to be older adults of Hispanic ethnicity; however, any ethnic background was accepted. Individuals with existing chronic conditions or physical limitations, such as diabetes, asthma or osteoarthritis, were included in the study with the approval of their healthcare provider. All testing was conducted at the Fitness Research Facility operated by the Department of Kinesiology at UTEP and in a similarly equipped recreation centre managed by the El Paso Parks and Recreation Department, Texas.

4.2.3 Sites and training protocol

Within the Melbourne study, the participating facilities were the Uniting AgeWell centres at Forest Hill, Oakleigh, Noble Park and Hawthorn. The first three operated HUR gyms and the fourth a conventional gym, providing exercise physiology programs. Based on ongoing research, HUR equipment, which was developed in Finland in 1989, uses innovative pneumatic technology and computerised smart card and smart touch systems that record clients' visits and work-outs (Helsinki University Research Australia, 2018a, 2018b). The conventional gym

offered exercise training programs using equipment such as treadmills, exercise bikes, dumbbells, TheraBands and foam mats, with strength and functional assessments as part of ‘standard care’ exercise training programs. Participants followed their own personal exercise programs as developed by the exercise physiologists or physiotherapists. The training duration was usually one hour, and the frequency varied depending on individual programs (generally once or twice per week). Programs ranged 2–3 sets with 8–20 repetitions. The Forest Hill and Oakleigh gyms included HUR Active Line equipment, such as pulleys, leg presses, hip abduction/adduction machines, leg flexion/extension machines, chest presses, rhomboid machines, trunk flexion/extension machines and iBalance and NuStep machines. Noble Park, which is the most recently opened facility, had the Premium Line equipment, including an ab/back roller and optimal rhomb (see Figure 4.5).

Figure 4.5. HUR gym in Noble Park.

The gym in Hawthorn used standard equipment, including dumbbells, barbells, kettlebells, TheraBands, steps, medicine balls, treadmills, exercise bikes, an elliptical cross trainer and a cable weight machine (see Figure 4.6).

Figure 4.6. Conventional gym in Hawthorn.

Apart from gym sessions, participants could take part in regular exercise groups. Tai chi and Pilates were offered at all sites except Noble Park. Forest Hill ran physio-based exercises. Oakleigh ran small exercise groups (using dumbbells, TheraBands and wearable weights) and an osteoporosis group. Noble Park ran a balance group (using rails, rocker boards and obstacles), strength groups (using hand weights, pulleys and rails) and individual exercises (using treadmills and recumbent bikes). Hawthorn ran sessions for strength conditioning (including medicine balls, the farmer's carry, ladder drills and jumps) and osteoporosis groups. These extra activities were not measured in this study but could potentially affect participants' physical performances.

Within the El Paso study, during the 16-week intervention, both ST and PT participants engaged in two 90-minute supervised exercise sessions weekly incorporating aerobic training, balance drills, and flexibility training following American College of Sports Medicine (ACSM) guidelines for older adult training. In addition to these training components, the ST group also performed strength training following ACSM recommendations, while the PT group performed power, agility, and mobility exercises instead. ST involved standard machine and free-weight training movements, such as squats, lunges, step ups, bench press, shoulder press, and dumbbell rows. PT exercises included medicine ball throws, bodyweight plyometrics, battle rope and hammer slams, as well as fast speed movements, including speed take-offs, agility ladder and the prowler sled push (see Table 4.2). These power exercises seemed to be fairly intense for subjects of that age group. Figure 4.7 illustrates ST and PT exercises performed during the intervention.

Figure 4.7. Illustration of strength training (left) and power/agility training (right) exercises during the intervention.

Both groups engaged in two 90-minute exercise sessions weekly for 16 weeks. The total training volume was equalised between the groups and research assistants supervised in 1:1 or 1:2 ratios to ensure proper training technique and to accommodate subjects' physical limitations. All subjects were tested before and after the 16-week program on strength, power, balance, speed and agility and underwent DEXA for body composition.

Table 4.2:

Strength and Power Training Groups, El Paso

ST group Focus: Exercise program following the ACSM recommendations		PT group Focus: Exercise program with additional power and agility training	
Warm-up	5 min	Warm-up	5 min
Two strength exercises	5 min	Two power exercises	5 min
Cardiovascular activity	5 min	Cardiovascular activity	5 min
Two strength exercises	5 min	Two strength exercises	5 min
Cardiovascular activity	5 min	Two agility exercises	5 min
Two strength exercises	5 min	Two strength exercises	5 min
Two balance exercises	10 min	Two balance exercises	10 min
Two strength exercises	5 min	Two strength exercises	5 min
One balance exercise	5 min	One balance exercise	5 min
Cardiovascular activity	10 min	Three agility exercises	10 min
Two strength exercises	5 min	Two strength exercises	5 min
Cardiovascular activity	15 min	Cardiovascular activity	15 min
Flexibility training	10 min	Flexibility training	10 min
Total	90 min		90 min

4.3 Measures

The Melbourne participants' demographic, exercise and gym data were obtained from the Uniting AgeWell system. For this study component, participants were assessed using standardised tests related to: (1) sarcopenia risk, (2) physical performance, (3) HRQoL and (4) nutrition. To that aim, they completed physical performance and body composition assessments as well as four surveys at baseline.

4.3.1 Diagnosis of sarcopenia

Both studies applied the FNIH, EWGSOP1 and EWGSOP2 criteria. Sarcopenia cut-off points according to different definitions have been presented in Table 3.1. Lean mass, muscle strength and physical performance were measured in all subjects. Assessments, including handgrip strength, gait speed, SPPB, TUG and 400mW, were chosen because they assess known risk factors of sarcopenia and have been shown to be well correlated with overall function, ADL and longevity; they are also simple and used in most current definitions of sarcopenia (Brennan-Olsen et al., 2019; Cruz-Jentoft et al., 2010, 2018; Studenski et al., 2014). Table 4.3 presents the assessments used in the Melbourne study.

Table 4.3:

Physical Performance and Body Composition Assessments, Melbourne

Component	Test	Equipment	Trials	Completion time
Upper-body strength	Handgrip strength	Handgrip dynamometer	One practice then two trials for both dominant and non-dominant hands; highest strength of three was used for scoring	5 min
Lower-body strength	Chair stand (sit-to-stand)	Chair, stopwatch	Five chair rises	5 min
Balance	Standing balance		Side-to-side, semi-tandem, tandem	5 min
Mobility	Four-metre gait speed	Stopwatch, measuring tape	Walking four metres; one practice then two trials at normal speed; the fastest time of three was used for scoring	5 min
Agility	TUG	Chair, cone	Stand from a chair, walk three metres at normal speed, turn around, walk back to the chair and sit down; one practice then two trials; fastest time of three was used for scoring	5 min
Cardiovascular fitness	400mW	Stopwatch, measuring tape, 20 m walking space	Walk a course of 10 metres 40 times as fast as possible, allowing for two rest stops; one trial	10 min
Body composition	BIA	BIA scale		7 min (incl. preparation)
Body composition	DEXA scan	DEXA machine (mobile DEXA bus)		8 min (incl. preparation)
Total				50 min

Key dates for assessments were displayed via posters (see Appendix H) and physical fitness tests were arranged with participants individually. For consistency across gyms and participants, all assessments were performed according to a research manual created specifically for this study, which could be easily adopted and used for ongoing data collection. An example of a TUG assessment/scoring sheet from the research manual is presented in Appendix I.

The El Paso subjects' physical fitness was assessed using a functional testing battery developed specifically for older adults (Reed-Jones, Dorgo, Hitchings & Bader, 2012) and the SPPB, which includes a chair rise, stair climb and balance, grip strength and walking speed measures. Muscular power and agility were assessed by laboratory tests (force plate data) (Rikli & Jones, 1999). Fitness tests included static and dynamic strength, power, balance, speed, agility and aerobic fitness measures (see Table 4.4). The applied tests have been validated (Rikli & Jones, 1999) and frequently used as functional fitness assessments for older adults. If more than one attempt was administered, the best attempt was analysed.

Table 4.4:

Assessments, El Paso

Component	Test	Equipment
Upper-body strength	Handgrip strength	Handgrip dynamometer
Upper-body muscular endurance	30 second arm curl	Dumbbell, chair, stopwatch
Lower-body strength	Isometric back-leg strength	Back-leg dynamometer
Lower-body muscular endurance	30-second chair stand	Chair, stopwatch
Upper-body power	Medicine ball chest pass throw	Medicine ball, measuring tape
Lower-body power	Vertical jump rate of force	Portable force platform
Agility	TUG (2.4 metre course)	Chair, cone
Mobility	Ramp walk	40-foot incline ramp
	Obstacle course	Cones, hurdles, steps, stopwatch
	Speed walk (flat ground and uphill maximum walking speed)	Stopwatch, measuring tape
Balance	Standing balance	-
Cardiovascular fitness	Six-minute walk (normal speed)	Stopwatch, measuring tape
Reaction time	Ruler drop	Ruler

4.3.1.1 Appendicular lean mass

A whole-body scan was performed using DEXA. The Melbourne study used Hologic Horizon A (MeasureUp, Melbourne, see Figure 4.8) and El Paso Lunar DPX-NT (GE Lunar Corp., Madison, WI, US). Within the Melbourne study, a mobile 'DEXA bus' was organised to visit the three gyms with the most participants, which were Forest Hill, Noble Park and Hawthorn. Participants from Oakleigh drove to their preferred DEXA location or taxi transport was organised for them.

Figure 4.8. Mobile DEXA bus (left: outside view; right: inside view).
Reprinted from *MeasureUp* (2016a).

DEXA is a non-invasive (fully clothed) and quick (four-minute) medical scan that obtains measures of muscle, bone and fat mass. The scan involves exposure to a very small amount of radiation as documented (see Appendix J). As part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about two millisieverts (mSv) each year. The effective dose from this study is about 0.01 mSv. At this dose level, no harmful effects of radiation have been demonstrated, as any effect is too small to measure, so the risk was believed to be minimal.

As part of the DEXA booking process, apart from individual arrangements with participants, I completed participants' registrations via the MeasureUp online system. Upon booking, participants received an automated email including booking details and information e.g., what to know before the scan, can I exercise or eat/drink before the test, or how much radiation does the scan expose me to). For maximum accuracy, participants were advised to wear clothing without metal (i.e., no under wire bras, zippers). If they had metal implants or other metal devices, they were allowed to have the scan, however the scanner might have slightly higher bone density readings as interpreting the metal as bone. Exercising, eating and drinking were allowed as per normal, but to track progress through follow-up scans, for reliability scan conditions would need to be roughly the same; about the same time of day,

similar food and fluid intake and training intensity, duration and timing (MeasureUp, 2016b). The booking confirmation also stated that DEXA radiation dose was equivalent to the radiation from a domestic flight from Sydney to Brisbane, which is very little, referring to the MeasureUp website for more details (MeasureUp, 2016c). Participants who did not have an email address were advised about the scan conditions on the day of testing, and thus had to remove metal things or clothing just before the scan. Since catering was provided during DEXA testing, participants were allowed to have a drink and fruit, but advised to come back for a larger meal afterwards.

ALM was defined as the sum of lean soft-tissue mass from both the arms and legs (Baumgartner et al., 1998). Relative ALM was obtained by normalising ALM to BMI according to FNIH and by normalising ALM to height^2 according to EWGSOP1 and EWGSOP2, as muscle mass is strongly correlated with height (Baumgartner et al., 1998; Heymsfield et al., 1990). Absolute and normalised parameters were reported in both studies, as age-related changes in lean mass and body size may affect loss of muscle mass with age (Suetta et al., 2019).

In addition, the participants' body composition was assessed using a BIA scale (Tanita dual frequency body composition analyser, model: TIDC360S, Wedderburn, Melbourne). The BIA scale is presented in Figure4.9 and its specifications in Appendix K.

Figure 4.9. BIA scale, Melbourne.

According to the research manual, BIA scale was not allowed for pregnant women and people with pacemakers since the electrical signal may interfere with its operation (Tanita, 2018). For participants' health sake, individuals with heart valves were also not allowed to use the scale. People with non-electronic implants (e.g., hip replacement) could use the scale, however any metallic implants in the body could affect the body fat readings. However, they would be able to track changes over time (Tanita Australia, 2019). Subjects were asked to step

on the scale in bare feet with arms away from the body for about a minute. Once the reading was complete, a slip with results was printed out automatically. Then the subject was allowed to step off the scale.

Using a BIA scale is standard gym practice; however, depending on the quality of the BIA device, there can be limitations in lean and fat mass measurements. As BIA scales do not involve radiation and are the most cost-effective, they will continue to be used in the gyms in future. DEXA results were correlated with BIA measurements to provide confidence in the accuracy of the BIA device. To maximise the numbers for analysis, and due to the very high correlations between DEXA and BIA variables, eight missing DEXA variables were substituted with the value calculated by the linear equation from the straight-line fit of the data. Other than bone mass, the R-values were over 0.9. Given the R-value for ALM was 0.938 (i.e., the R^2 was 0.8799), thus 88% of the variance of total lean mass can be attributed to the predicted muscle mass; PMM obtained from BIA), this was a reasonable and fairly accurate replacement. Figure 4.10 shows the correlations between the DEXA and BIA variables.

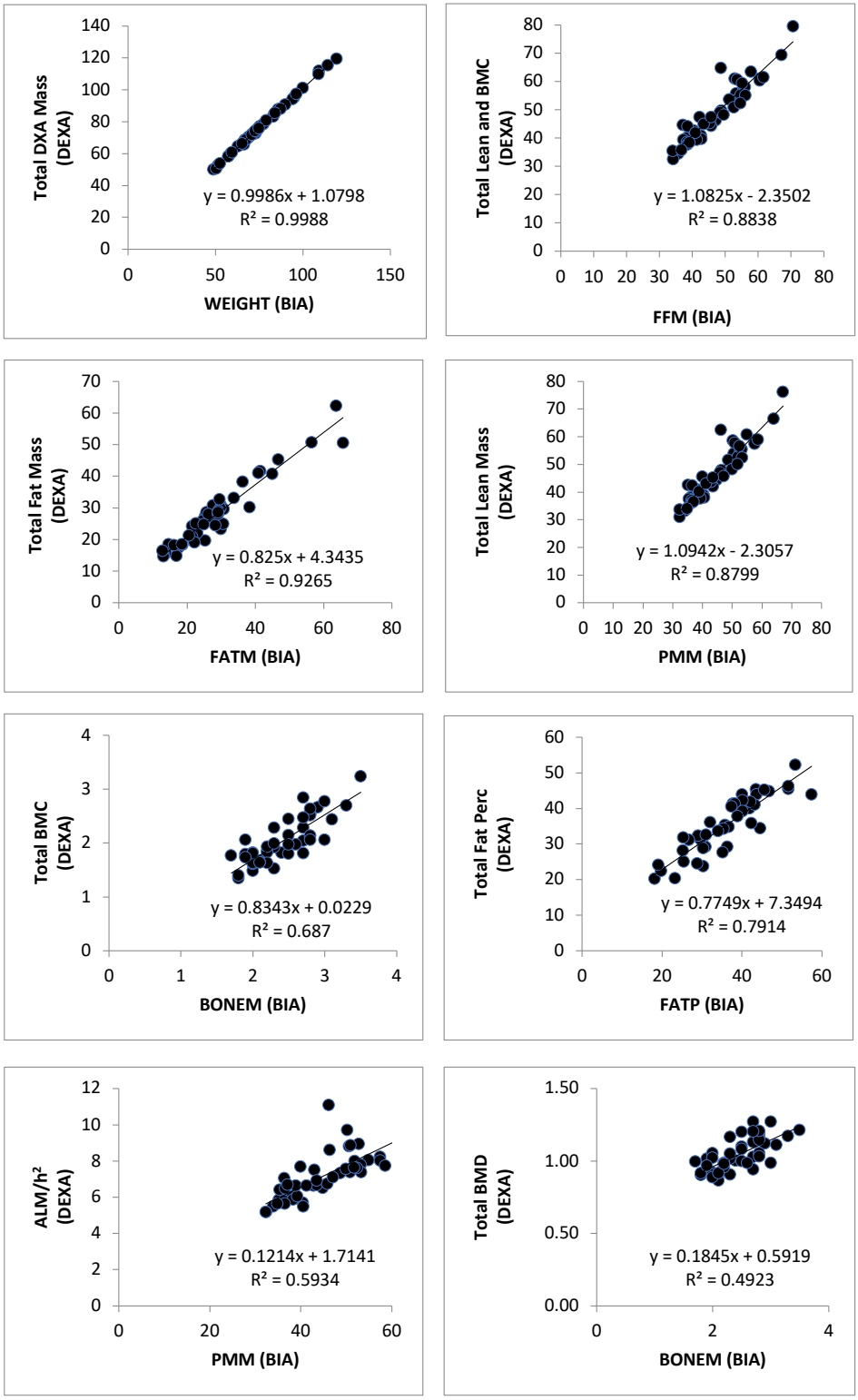

Figure 4.10. Correlations between DEXA and BIA variables.

BMC = bone mineral content; FFM = fat free mass (PMM+BONEM); FATM = fat mass; PMM = predicted muscle mass; FATP = fat percentage; ALM/h^2 = appendicular lean mass normalised for height^2; BONEM = bone mass. Vertical axe represents DEXA and horizonal BIA variables.

4.3.1.2 Muscle strength

Handgrip strength was measured as recommended by all three definitions. In accordance with the revised EWGSOP2, the chair-stand test was also performed as part of the SPPB.

Handgrip strength (kg): Handgrip strength was assessed as the static grip strength measured with a handgrip dynamometer. The Melbourne study used Jamar Plus+ (SI Instruments, Adelaide), which is illustrated in Figure 4.11. Its specifications are presented in Appendix L. The El Paso study used Hydraulic Hand Dynamometer ER HIRes (Product: 12-0246; SN:64202460, see Appendix L). The handgrip dynamometer was used in a seated position, with the forearm resting on the arm rest and the elbow at 90 degrees. The handgrip of the dominant hand was recorded. Participants performed one practice and two trials for each hand (dominant and non-dominant) by squeezing as hard as possible. The best of six trials was analysed (Roberts et al., 2011).

Figure 4.11. Handgrip dynamometer, Melbourne.

Chair stand (s): This test assessed leg strength and included one practice and one trial. Participants were asked to stand up from a chair and sit down as quickly as possible five times without stopping, with their arms folded across their chest or abdomen (see Figure 4.12). The practice was a single chair stand without a stopwatch. If the subject was not able to perform the single chair stand without using the arms, then repeated chair stands were not performed. Time was measured via a sports stopwatch (cat. no. XC027, Jaycar, Melbourne, Australia; see Appendix M).

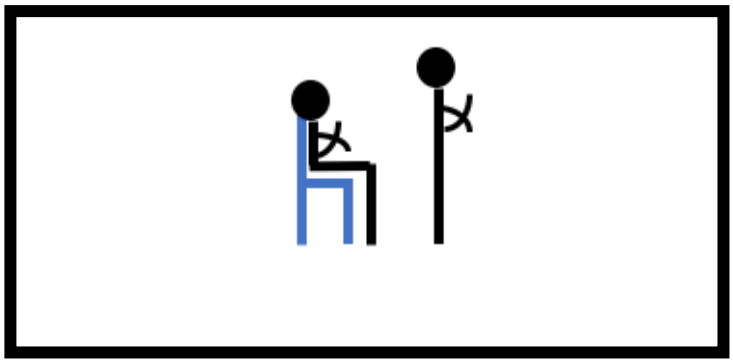

Figure 4.12. Chair-stand test, Melbourne.

4.3.1.3 Physical performance

The Melbourne sample's physical performance was assessed by gait speed, SPPB, TUG and 400mW tests. To match the tests related to the sarcopenia components with the Melbourne study, only handgrip strength, gait speed and TUG were used for analysis in the El Paso study.

4.3.1.3.1 Gait speed (m/s)

The purpose of this test was to assess mobility. Within the Melbourne study, gait speed was assessed from a four-metre walk that was the middle four metres of a six-metre course performed at the participants' normal speed as part of the SPPB. The participants performed the test three times: one practice followed by two trials (see Figure 4.13). El Paso's gait speed was assessed from a six-minute walk that was performed at the participants' normal speed on a treadmill using a stopwatch (Accusplit Model Name: Pro Survivor 601X 3V.1).

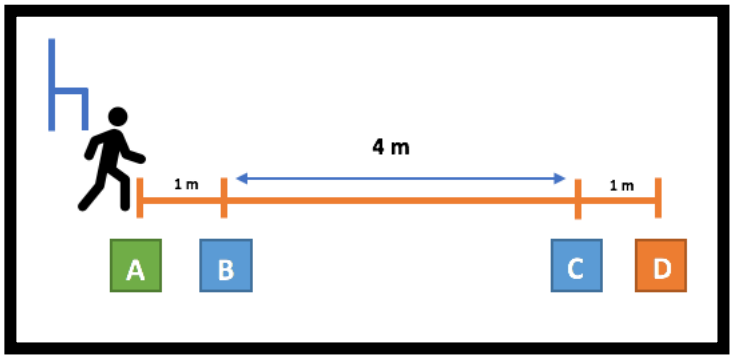

Figure 4.13. Four-metre gait speed test, Melbourne.

4.3.1.3.2 Short physical performance battery

The SPPB involved three standing balance stances with different foot positions: side-by-side, semi-tandem and tandem; measurement of normal gait speed as detailed above; and the chair-stand test (see Figure 4.14). The tests were conducted one after the other (unless the participant requested a short rest) and each component was scored a maximum of four points, so the highest total score was 12. A SPPB score 0–6 implies low performance, 7–9 intermediate

performance and 10–12 high performance (Cruz-Jentoft et al., 2010). SPPB scores ≤ 6 are associated with a higher rate of falls (Veronese et al., 2014) and ≤ 10 with decreased mobility (Vasunilashorn et al., 2009). Patients with a poor SPSS score (0–4) at hospital discharge have a higher risk of re-hospitalisation (Volpato et al., 2010). An SPPB score below 10 is predictive of all-cause mortality (Cesari et al., 2008; Pavasini et al., 2016).

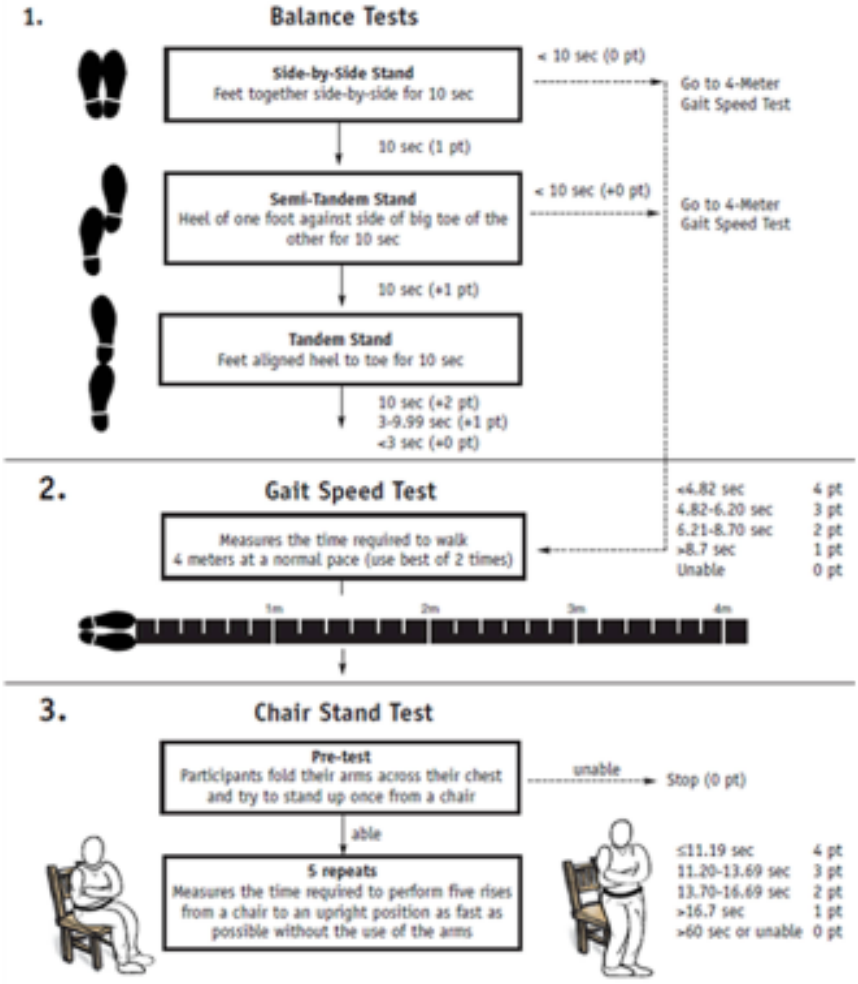

Figure 4.14. Short physical performance battery tests, Melbourne.
Reprinted from Riskowski, Hagedorn, Dufour & Hannan (2012).

4.3.1.3.3 Timed up and go (s)

This test assessed mobility, balance and agility. The Melbourne study's TUG measured the time it took a subject to stand up from a chair, walk across the three-metre course at their normal speed, turn around the cone, return to the chair and sit down, with one practice trial followed by two recorded trials (Bloch, Jønsson & Kristensen, 2017) (see Figure 4.15). The best of three trials was considered for analysis. The El Paso study's TUG was performed on an eight-foot (approx. 2.4-metre) course.

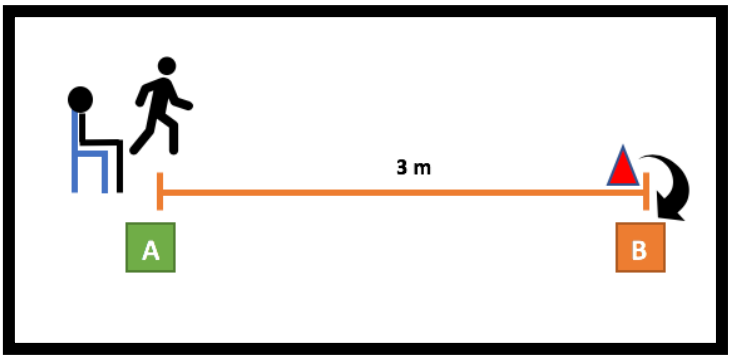

Figure 4.15. Timed up and go test, Melbourne.

4.3.1.3.4 400-metre walk

The purpose of this test was to assess mobility and cardiovascular fitness. The course is normally to walk 20 metres 20 times as fast as possible. However, due to limited space in the gyms, participants walked 10 metres 40 times, doing a total of 20 rounds back and forth (see Figure 4.16). The test was only performed once and was the final test performed on any given day.

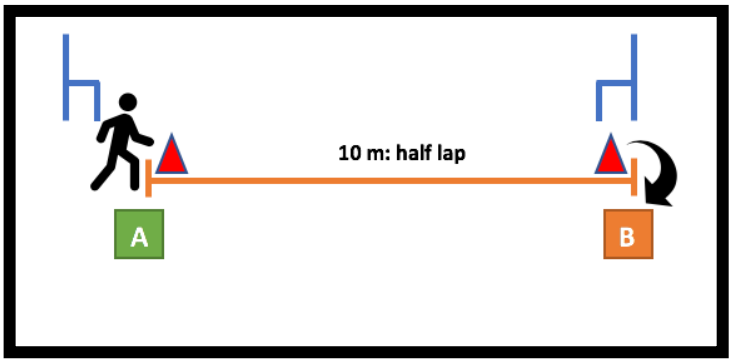

Figure 4.16. 400-metre walk test, Melbourne.

4.3.2 Anthropometrics

Within the Melbourne study, height (Charder HM200P, Charder Electronic Coltd, Tachung City, Taiwan) was measured with footwear, headwear and heavy items of clothing removed. Weight was measured as the sum of total fat mass, total lean and bone mineral content (BMC) derived from DEXA. For the El Paso study, the SECA 213 stadiometer (SECA, 2017a) and SECA 803 electronic scales were used (SECA, 2017b). BMI was calculated as weight (kg) / height^2 (m).

4.3.3 Self-reported measures

Within the Melbourne study, in addition to physical and body composition assessments, participants were asked to complete four surveys: SARC-F (see Appendix A), PASE (see Appendix B), AQoL-4D (see Appendix C) and AES (see Appendix D). Table 4.5 summarises

all four surveys. Permission to use these validated surveys was obtained. To match surveys with the Melbourne study, the El Paso study used the identical AQoL-4D in 2016.

Table 4.5:

Surveys, Melbourne

No.	Survey	Instrument	Items	Purpose	Country of origin	Completion time
1.	Sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls	SARC-F	5	To predict sarcopenia risk for poor functional outcomes	US	3 min
2.	Physical Activity Scale for the Elderly	PASE	10	To assess physical activity status	US	15 min
3.	Assessment of Quality of Life	AQoL-4D	12	To obtain data on HRQoL: independent living, mental health, relationships and senses	Australia, Monash University	7 min
4.	Australian Eating Survey	AES for adults	15	To assess nutritional adequacy of dietary intake tailored to age, gender and life stage	Australia, University of Newcastle	25 min
Total						50 min

4.3.3.1 Self-reported function (via SARC-F)

To measure self-reported function in the Melbourne sample, participants were asked to complete a SARC-F survey including five components: strength, assistance in waking, rise from a chair, stair climb and falls (Malmstrom et al., 2016; Malmstrom & Morley, 2013; Morley & Malmstrom, 2014). SARC-F was associated with QoL, hospitalisation, use of emergency care and four-year mortality in community-dwelling older Taiwanese populations (Wu et al., 2016). When compared to the FNIH definition, the validity of SARC-F was limited (Rolland et al., 2017). SARC-F could predict adverse outcomes in the future with comparable power to EWGSOP1, International Working Group on Sarcopenia and Asian Working Group for Sarcopenia (Woo, Leung & Morley, 2014). SARC-F may detect severe sarcopenia cases and has been proposed by EWGSOP2 to identify sarcopenia risk before performing actual measurements on clinical suspicion (Cruz-Jentoft et al., 2018). SARC-F scale scores range from 0 to 10 (0–2 for each component, with 0 being the best and 10 being the worst) and subjects who scored four or higher were assessed as being at risk of sarcopenia (Malmstrom & Morley, 2013).

4.3.3.2 Self-reported physical activity (via PASE)

Within the Melbourne study, physical activity status over the past week was assessed via the PASE, including activities such as walking and light, moderate or strenuous sport (Washburn, et al., 1993). Total PASE scores were calculated by multiplying the amount of time spent on each activity by respective weights and adding up all activities (Washburn et al., 1993). The PASE score does not have any cut-off or refer to a specific state (e.g., active vs non-active), but the means vary by age, gender (Loland, 2002; Washburn, Smith, Jette, & Janney, 1993), health status (Martin et al., 1999; Svege, Kolle, & Risberg, 2012) and in sarcopenic vs non-sarcopenic populations (Curcio et al., 2017; Verlaan et al., 2017). The PASE score is curvilinearly related to muscle mass and strength and may identify older populations at higher risk of sarcopenia (Curcio at al., 2017).

4.3.3.3 Self-reported health-related quality of life (via AQoL-4D)

The decline of QoL has been widely proven in older adults, although much of the past research has been done using generic QoL instruments to assess HRQoL, especially the 36-item Short Form Survey (SF-36) (Da Silva et al., 2019; Go et al., 2013; Krist et al., 2013). Sarcopenia is associated with poorer HRQoL for the domain of physical function using the SF-36 and EuroQo1-5 dimension (EQ-5D) instruments (Go et al., 2013). The recent Sarcopenia and QoL (SarQoL®) seems to be the first questionnaire on HRQoL that was specifically designed and validated for sarcopenia, showing good correlations with some domains of the SF-36 and EQ-5D (Beaudart et al., 2017; Beaudart et al., 2018). Associations between the components of sarcopenia and HRQoL using the AQoL-4D are unknown. To obtain psychometric data on HRQoL, participants in the Melbourne and El Paso studies were asked to complete a 12-item AQoL-4D assessing four dimensions: independent living (self-care, household tasks and mobility), mental health (sleeping, worrying and pain), relationships (friendships, isolation and family role) and senses (seeing, hearing and communication) over the past week. A utility score was used in this study (Assessment of Quality of Life, 2014). The AQoL-4D utility score with negative utilities represents health states worse than death; zero represents death, while one indicates full health (Hawthorne, Korn & Richardson, 2013).

4.3.3.4 Self-reported nutrition (via AES)

Nutrition is an important part of muscle mass and function (Cooper & Sayer, 2017; Fujita & Volpi, 2004; Millward, 2012; Robinson et al., 2017; Yanai, 2015). Therefore, the Melbourne sample's participants were also asked to complete the AES for adults, comparing food and nutrient intake with nutrition targets in the past three to six months (the University of

Newcastle Australia, 2018). The ARFS is 73 points, which is the sum of the scores from eight group categories: vegetables, fruit, protein foods (meat/flesh), protein foods (meat/flesh alternatives), grains, breads, cereals, dairy, water and extras (see Table 4.3). A higher ARFS score implies healthier eating patterns and dietary intake that is of higher nutritional quality (the University of Newcastle, 2016) (see Table 3.1). The ARFS has been validated for children (Burrows et al., 2014; Collins et al., 2015; Marshall et al., 2012) and adults (Collins et al., 2015); however, this is its first use in a potentially sarcopenic population. Since poor protein and energy intake is linked to sarcopenia (Liao et al., 2017, 2019; Okamura et al., 2019), this study specifically analysed protein and energy intake obtained from AES. AES guidelines are presented in Appendix N.

Survey score ratings are summarised in Table 4.6. Upon completion of the surveys, participants were provided with individual reports regarding DEXA (see Appendix O), BIA (see Appendix P) and AES (see Appendix Q), as well as a DEXA fact sheet (see Appendix R) and instructions to MeasureUp's online results platform to view DEXA results.

Table 4.6:

Survey Score Ratings, Melbourne

SARC-F	PASE	AQoL-4D	AES
Total score: 10 ≥4 sarcopenia risk	Total score: open	Total utility score: 1 -0.04-1.0 where negative utilities represents health states worse than death, 0 represents death, while 1 indicates full health	Total ARFS: 73 1. Vegetables: 21 2. Fruit: 12 3. Protein foods: meat/flesh:7 4. Protein foods: meat, alternatives: 6 5. Grains, breads, cereals: 12 6. Dairy: 11 7. Water: 1 8. Extras: 2 Total score rating <33: needs work 33-38: getting there 39-46: excellent 47+: outstanding

Adapted from Malmstrom & Morley (2013); Curcio, Liguori, Cellulare, Sasso, Della-Morte, Gargiulo … Abete (2017); Hawthorne, Korn & Richardson (2013); University of Newcastle (2016).

In the context of the Melbourne study, the first three surveys were completed on paper on the same days as DEXA testing and followed up later via email or phone (see Table 4.7). AES was offered online as well as hard copy since some older participants had no email and/or were unfamiliar with computers, which I subsequently transposed online.

Table 4.7:

Completion of Surveys in the Various Formats, Melbourne

No.	Survey	Paper	Online	Phone	Total
1.	SARC-F	97	5	3	105
2.	PASE	96	5	0	101
3.	AQoL-4D	97	4	1	102
4.	AES for adults	34	53	3	90

SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls; PASE: Physical Activity Scale for the Elderly; AQoL-4D: Assessment of Quality of Life; AES: Australian Eating Survey.

4.4 Statistical analysis

The level of significance was set at p-value < 0.05 at 95% confidence intervals. Data is presented as mean (SD) or frequency (%) unless otherwise specified. All analyses were performed in IBM SPSS Statistics for Mac, version 25 (IBM Corp., Armonk, NY, US) using five steps:

1. Descriptive statistics were performed on continuous variables and frequency analyses on nominal data.
2. Chi-square tests were used to test for differences between HUR and conventional gym training for sarcopenia prevalence according to the FNIH, EWGSOP1 and EWGSOP2 definitions.
3. Continuous data was assessed for normality and non-parametric tests were used as appropriate. Spearman correlations explored associations for survey scores (SARC-F, AQoL-4D utility score, PASE score and AES protein and energy intake) and ARFS with sarcopenia components (muscle strength, lean mass and physical performance). The Spearman coefficient was interpreted as weak (0.1–0.3), moderate (0.4–0.5) and strong (0.6–0.9).
4. Independent sample t-tests were applied to compare sarcopenia components and nutritional survey scores between the HUR and conventional gyms.

5. One-way between-groups analysis of variance (ANOVA) was conducted to explore the effect of years trained at the gym and weekly gym visits on sarcopenia components.

Given that the El Paso study had post-data available, in addition to descriptive statistics, frequency analyses and Spearman correlations, it incorporated the following analyses:

1. McNemar (dichotomous data) was performed to test for significant differences between sarcopenia prevalence at pretest (T1) and after 16 weeks of training (T2).
2. Paired-sample t-tests were conducted to evaluate the effect of training on sarcopenia components (muscle strength, lean mass and physical performance) and HRQoL for the whole sample.
3. Repeated measures of ANOVA were used to assess the effect of two interventions (ST and PT) on sarcopenia components and HRQoL.

Chapter 5: Results

5.1 Baseline characteristics

This section explores the extent to which the different training types and locations of these two studies affect prevalence of sarcopenia and its components and the association with HRQoL. It should be noted that there were differences in pretest characteristics, training methods, training duration/frequency and outcome measures between studies. Study 1 examined an older population in Melbourne in which the baseline data were collected for participants that had undergone strength/resistance training at three HUR gyms and one conventional gym for about a year (M = 1.04, SD = 0.51), visiting the gyms about once a week (M = 1.03; SD = 0.48). The El Paso sample was exercise naïve and commenced a program in which exercise was specifically prescribed, with two training sessions per week. One group performed strength training following ACSM guidelines and another group specifically focused on power training.

Descriptive characteristics for 105 Australian adults aged 61–83 years who participated in HUR and conventional gyms, and for 85 US adults aged 59–89 years are shown in Table 5.1. Independent sample t-tests were performed to compare baseline characteristics between Melbourne and El Paso sites. Demographically, the Melbourne sample was larger (n = 105) than the El Paso sample (n = 85). The Melbourne cohort was significantly older than its El Paso counterpart. Both studies had more women participating than men (i.e., 69% in Melbourne and 59% in El Paso). Chi-square tests showed that proportions of women were not significantly different between sites. While the Australian cohort had English/Australian and non-English/Australian ethnicity groups, the US cohort comprised Caucasian and Hispanic groups. The results showed that the proportions of English/Australian and Caucasian groups were significantly different. Non-significantly, there were more English/Australians in Melbourne compared to Caucasians in El Paso. No significant difference was observed in proportion between the HUR gym and ST groups. However, there was a non-significant trend for HUR gyms to be higher in participant numbers than the ST group.

Anthropometrically, the UTEP cohort was significantly taller than the Uniting AgeWell cohort, but there was no significant difference in weight between sites. However, non-significantly, the El Paso sample was heavier than the Melbourne sample. There were also no significant differences in BMI between sites (see Table 5.1). In the Melbourne sample, 1.9% were underweight (BMI $\geq$ 18.5–24.9), 31.4% normal weight (BMI $\geq$ 18.5), 34% overweight

(BMI ≥ 25–29.9), and 32.4% obese (BMI ≥ 30%). In the El Paso cohort, 23.5% were normal weight, 38.8% overweight and 37.6% obese. While there were no significant differences in total lean mass, ALM or ALM/BMI between sites, El Paso participants had significantly higher total fat mass, total fat % and BMC than Melbourne participants. However, ALM normalised for height^2 was also higher in that group than in the Melbourne group. Regarding physical assessment, the UTEP cohort scored significantly higher handgrip strength than the Uniting AgeWell cohort. In addition, at baseline, UTEP participants had significantly faster gait speed than the Melbourne cohort that had trained for about a year on average.

Table 5.1:

Difference in Baseline Characteristics between Melbourne (n = 105) and El Paso (n = 85)

	Baseline characteristics	Melbourne (n = 105)	El Paso (n = 85)	P-value for difference*
Demographics	Age (yr), mean (ST)	76.89 (6.19)	67.69 (6.78)	< 0.001
	Women (%)	69	59	0.163**
	Ethnicity (%) English/Australian (Melbourne) Caucasian (El Paso)	81	59	0.003**
Training	HUR gym (Melbourne) Strength training group (El Paso) (%)	72	66	0.378**
Anthropometric measurements	Height (cm), mean (ST)	163.21 (8.79)	166.78 (9.99)	0.011
	Weight (kg), mean (ST)	75.55 (17.17)	80.28 (19.60)	0.078
	BMI (kg/m^2), mean (ST)	28.32 (5.91)	28.71 (5.66)	0.644
DEXA	Total lean mass (kg), mean (SD)	46.69 (10.11)	44.22 (11.75)	0.121
	Total fat mass (kg), mean (SD)	26.77 (10.71)	31.55 (11.55)	0.004
	Total fat (%), mean (SD)	34.70 (8.24)	41.27 (9.59)	< 0.001
	Total BMC (kg/cm^2), mean (SD)	2.10 (0.46)	2.69 (0.58)	< 0.001
Lean mass	ALM (kg), mean (SD)	18.82 (4.81)	18.91 (5.38)	0.909
FNIH	ALM/BMI (kg/m^2), mean (SD)	0.67 (0.16)	0.67 (0.19)	0.892
EWGSOP1 & 2	ALM/h^2 (kg/m^2), mean (SD)	6.99 (1.30)	11.22 (2.66)	< 0.001
Muscle strength	Handgrip strength (kg), mean (SD)	25.90 (8.30)	31.2 (13.2)	0.001
	Chair stand (s), mean (SD)	10.03 (3.83)	-	-
Physical performance	Gait speed (m/s), mean (SD)	1.31 (0.25)	1.47 (0.36)	0.001
	TUG (s), mean (SD) Melbourne: 3-metre course El Paso: 2.4-metre (8 ft) course	8.62 (3.72)	4.92 (1.46)	< 0.001
	SPPB (score) median (IQR)	12.00 (6)	-	-
	400mW (min), mean (SD)	5.51 (1.71)	-	-
Survey	AQoL-4D (score; n = 102), mean (SD)	0.69 (0.22)	0.82 (0.16)	< 0.001
	SARC-F (score; n = 105), mean (SD)	1.71 (1.86)	-	-
	PASE (score; n = 101), mean (SD)	128.87 (58.97)	-	-
	AES-ARFS protein (g; n = 99), mean (SD)	101.77 (35.71)	-	-
	AES-ARFS energy (kJ; n = 99), mean (SD)	9249.62 (2898.10)	-	-
	AES-ARFS total (score; n = 99), mean (SD)	35.33 (8.96)	-	-

HUR: Helsinki University Research; ST: strength training, BMI: body mass index; BMC: bone mineral content; ALM: appendicular lean mass, SPPB: short physical performance battery; TUG: timed up and go test; FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; AQoL-4D: Assessment of Quality of Life; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls; PASE: Physical Activity Scale for the Elderly; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score (obtained from the AES). * All analyses are independent sample t-tests except **chi-square tests; $p < 0.05$ are in green text.

5.2 Sarcopenia prevalence

Sarcopenia was diagnosed according to FNIH, EWGSOP1 and EWGSOP2 using the same cut-off points for both studies. However, SARC-F was not recorded in the El Paso study. Both studies reported a low prevalence of sarcopenia. Chi-square tests showed no significant difference in sarcopenia prevalence according to FNIH ($p = 0.319$) and EWGSOP2 sarcopenia probable ($p = 0.217$) between sites. Sarcopenia prevalence of the Melbourne sample according to FNIH, EWGSOP1 and EWGSOP2 is presented in Figure 5.1. The highest prevalence of 10.5% was recorded according to EWGSOP1. There were 23 people identified as presarcopenic and none had severe sarcopenia. Both EWGSOP2 (sarcopenia confirmed) and FNIH diagnosed sarcopenia were observed in 3.8% of the sample. Within EWGSOP2, the SARC-F survey identified 14 participants at risk of sarcopenia. Based on low muscle strength, 18% of participants were sarcopenia probable. However, less than 4% of participants had low muscle strength and low lean mass (confirmed sarcopenia), and less than 3% of participants had all of low muscle strength (assessed by handgrip strength), low lean mass (assessed by ALM/h^2) and low physical performance (assessed by gait speed) (severe sarcopenia). Only one new participant joined the gym at the commencement of the research and did not have sarcopenia according to the three definitions. All other participants had been training for about a year, on average.

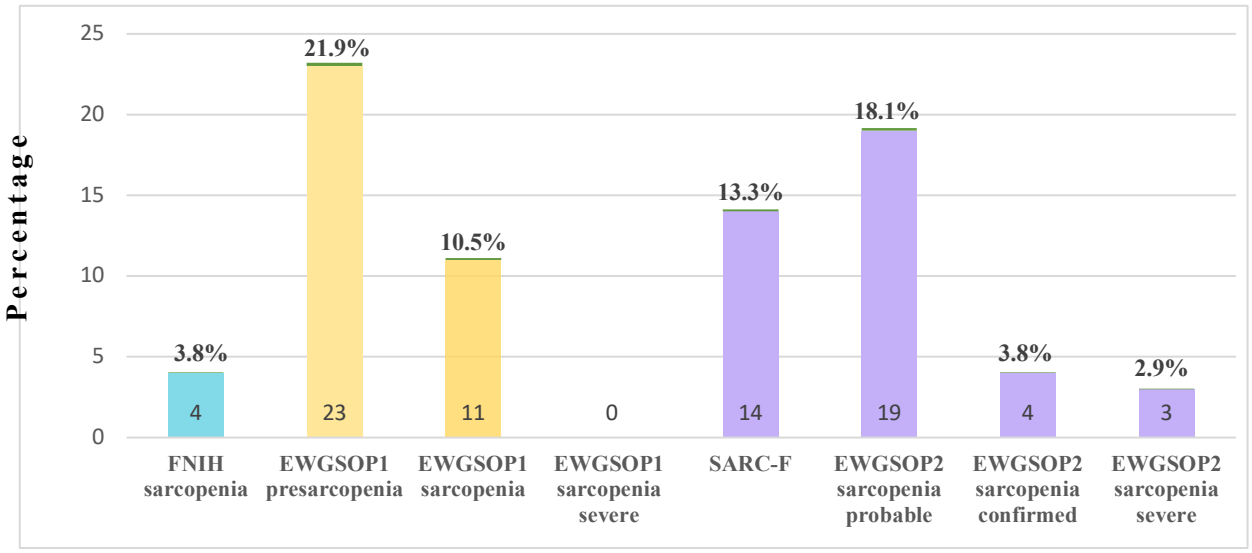

Figure 5.1. Sarcopenia prevalence according to different definitions, Melbourne (n = 105). All data are frequency (%) or counts (n). FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls.

While subjective SARC-F predicted that 14 individuals had increased risk of sarcopenia, the three objective definitions identified lower numbers with sarcopenia (see Table 5.2). SARC-F predicted one case of sarcopenia according to FNIH and EWGSOP1, four cases of sarcopenia probable but none were EWGSOP2 sarcopenia confirmed or severe according to EWGSOP2. No person had sarcopenia according to all definitions—FNIH, EWGSOP1 and EWGSOP2—but some were identified by two of the three definitions.

Table 5.2:

Overlap of Sarcopenia Prediction and Detection across Different Definitions, Melbourne

	FNIH sarcopenia (4)	EWGSOP1 pre-sarcopenia (23)	EWGSOP1 sarcopenia (11)	EWGSOP2 sarcopenia probable (19)	EWGSOP2 sarcopenia confirmed (4)	EWGSOP2 sarcopenia severe (3)
SARC-F (14)	1	2	1	4	0	0
FNIH sarcopenia (4)	-	0	1	4	0	0
EWGSOP1 presarcopenia (23)	0	-	11	0	1	1
EWGSOP1 sarcopenia (11)	1	11	-	5	4	3

All data are counts (n). FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls.

Chi-square tests (see Table 5.3) indicated a significant association between FNIH and EWGSOP2 sarcopenia probable, and EWGSOP2 sarcopenia confirmed. No significant association was observed between FNIH and EWGSOP1. EWGSOP1 was significantly associated with all EWGSOP2 stages (i.e., EWGSOP2 sarcopenia probable, confirmed and severe). Despite its proposed role as an initial screening tool, there was no significant association between SARC-F and any of the sarcopenia definitions.

Table 5.3:

Associations between Different Sarcopenia Definitions (n = 105), Melbourne

Definition	1.	2.	3.	4.	5.	6.
1. FNIH	-	0.333	0.484	< 0.001**	0.024*	0.727
2. EWGSOP1	0.333	-	0.662	0.013*	< 0.001**	< 0.001**
3. SARC-F	0.484	0.662	-	0.274	0.424	0.491
4. EWGSOP2 sarcopenia probable	< 0.001**	0.013*	0.274	-	< 0.001**	< 0.001**
5. EWGSOP2 sarcopenia confirmed	0.024*	< 0.001**	0.424	< 0.001**	-	< 0.001**
6. EWGSOP2 sarcopenia severe	.0727	< 0.001**	0.491	< 0.001**	< 0.001**	-

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. All analyses are chi-square tests; ** $p < 0.01$ (2-tailed); * $p < 0.05$ (2-tailed) are in green text.

Chi-square tests (see Tables 5.4–5.6) revealed no significant differences between age groups, gender or ethnicity for sarcopenia prevalence. There were no cases of sarcopenia in the lowest age group (60–69 years) except for SARC-F (1%). Sarcopenia began to be detected in the 70–79 age group and was prevalent in subjects aged 80–83 years, according to all definitions (see Table 5.4).

Table 5.4:

Difference in Prevalence of Sarcopenia According to Different Definitions for Older Adults by Age Groups (n = 105), Melbourne

Definition	60–69 (n = 12)	70–79 (n = 54)	80–83 (n = 39)	P-value for difference*
FNIH, n (%)	0 (0%)	2 (1.9%)	2 (1.9%)	0.718
EWGSOP1, n (%)	0 (0%)	5 (4.8%)	6 (5.7%)	0.288
SARC-F, n (%)	1 (1%)	4 (3.8%)	9 (8.6%)	0.078
EWGSOP2 sarcopenia probable, n (%)	0 (0%)	11 (10.5%)	8 (7.6%)	0.224
EWGSOP2 sarcopenia confirmed, n (%)	0 (0%)	2 (1.9%)	2 (1.9%)	0.718
EWGSOP2 sarcopenia severe, n (%)	0 (0%)	1 (1.0%)	2 (1.9%)	0.529

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. *All analyses are chi-square tests.

Non-significantly, more women had sarcopenia than men, regardless of the definitions (all $p > 0.05$; see Table 5.5).

Table 5.5:

*Difference in Prevalence of Sarcopenia According to Different Definitions for Older Adults by Gender (*n = *105), Melbourne*

Definition	Men (n = 33)	Women (n = 72)	P-value for difference*
FNIH, n (%)	1 (1.0%)	3 (2.9%)	0.778
EWGSOP1, n (%)	3 (2.9%)	8 (7.6%)	0.754
SARC-F, n (%)	6 (5.7%)	8 (7.6%)	0.322
EWGSOP2 sarcopenia probable, n (%)	5 (4.8%)	14 (13.3%)	0.596
EWGSOP2 sarcopenia confirmed, n (%)	1 (1.0%)	3 (2.9%)	0.778
EWGSOP2 sarcopenia severe, n (%)	1 (1.0%)	2 (1.9%)	0.943

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. *All analyses are chi-square tests.

Ethnicity included two groups: English/Australians and non-English Australians (see Table 5.6). The non-English Australian group comprised Asians (n = 8), Europeans (n = 8),

South Africans (n = 3), Latin Americans (n = 1) and New Zealanders (n = 1). There was a non-significant trend for English/Australians to be more sarcopenic than non-English/Australians according to SARC-F and EWGSOP2 sarcopenia probable, but not for FNIH and EWGSOP2 sarcopenia confirmed where sarcopenia prevalence was the same.

Table 5.6:

Difference in Prevalence of Sarcopenia According to Different Definitions for Older Adults by Ethnicity (n = 105), Melbourne

Definition	English/ Australian (n = 85)	Non-English/ Australian (n = 20)	P-value for difference*
FNIH, n (%)	2 (1.9%)	2 (1.9%)	0.108
EWGSOP1, n (%)	7 (6.7%)	4 (3.8%)	0.122
SARC-F, n (%)	11 (10.5%)	3 (2.9%)	0.807
EWGSOP2 sarcopenia probable, n (%)	16 (15.2%)	3 (2.9%)	0.689
EWGSOP2 sarcopenia confirmed, n (%)	2 (1.9%)	2 (1.9%)	0.108
EWGSOP2 sarcopenia severe, n (%)	2 (1.9%)	1 (1.0%)	0.523

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. *All analyses are chi-square tests.

In the El Paso sample, the prevalence of sarcopenia at baseline (T1) was 7.1% according to FNIH, but no participant had sarcopenia based on EWGSOP1 or EWGSOP2 (see Figure 5.2). Sarcopenia was not detected with EWGSOP1 or EWGSOP2 on the basis of an absence of low lean mass. However, 11.8% of the sample had sarcopenia probable according to EWGSOP2. Following 16 weeks of training (T2), the prevalence of FNIH sarcopenia and EWGSOP2 sarcopenia probable was 4.7% and 5.9% (reductions of 44% and 50%, respectively).

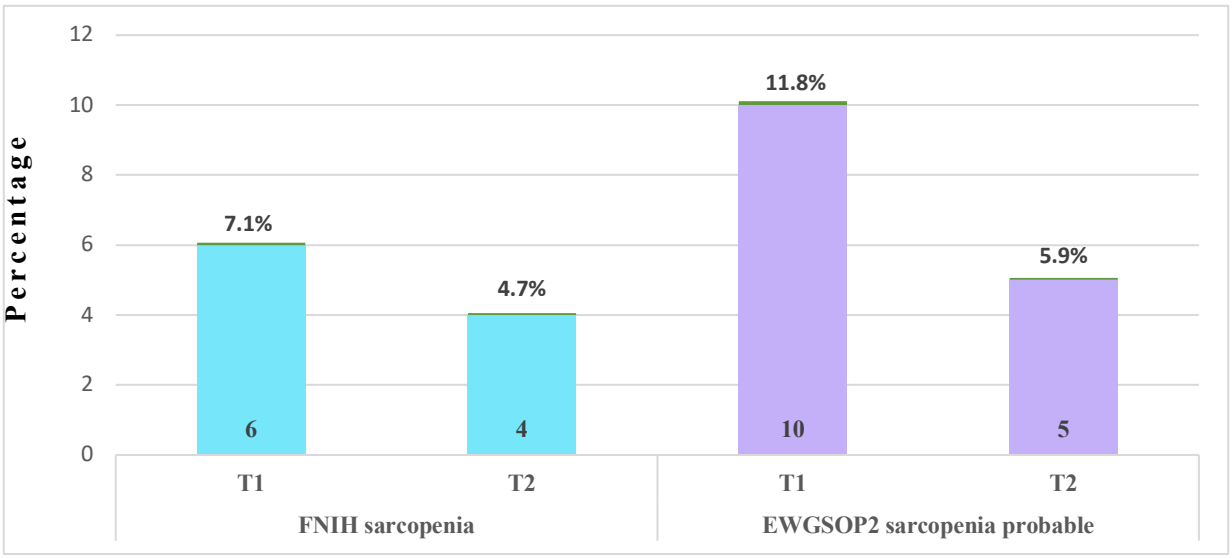

Figure 5.2. Sarcopenia prevalence at pre- and post-test according to different definitions, El Paso (n = 85). All data frequency (%) or counts (n). FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People, T1: pretest; T2: post-test.

The same six participants at the pretest stage and the same four participants after the intervention, which were confirmed with sarcopenia according to FNIH, were also detected within EWGSOP2 sarcopenia probable. McNemar's test showed no significant change in the proportion of participants detected with sarcopenia according to FNIH (see Table 5.7) or with sarcopenia probable according to EWGSOP2, when compared with the proportion prior to the intervention (p = 0.500; see Table 5.8).

Table 5.7:

Difference in Change in Prevalence of Sarcopenia According to FNIH for Older Adults, El Paso (n = 85)

Definition	FNIH sarcopenia (T2)		P-value for change*
FNIH sarcopenia (T1)	No sarcopenia	Sarcopenia	0.500
No sarcopenia	79	0	
Sarcopenia	2	4	

FNIH: Foundation for the National Institutes of Health sarcopenia project. *All analyses are McNemar's tests

According to EWGSOP2, non-significantly, six subjects with sarcopenia probable at the pretest stage tested non-sarcopenic post-test, and four remained with sarcopenia probable. However, one subject with no sarcopenia probable at the pretest stage was detected with sarcopenia probable post-test (p = 0.125; see Table 5.8).

Table 5.8:

Difference in Change in Prevalence of Sarcopenia According to EWGSOP2 Sarcopenia Probable for Older Adults, El Paso (n = 85)

Definition	EWGSOP2 sarcopenia probable (T2)		P-value for change*
EWGSOP2 sarcopenia probable (T1)	No sarcopenia	Sarcopenia	0.125
No sarcopenia	74	1	
Sarcopenia	6	4	

EWGSOP: European Working Group on Sarcopenia in Older People. *All analyses are McNemar's tests.

Before the intervention, chi-square tests revealed significant differences between age groups for sarcopenia (see Table 5.9). Sarcopenia prevalence increased with age according to FNIH. A similar trend occurred within EWGSOP2 sarcopenia probable; however, the prevalence remained the same in the 70–79 and 80–89 age groups.

Table 5.9:

Difference in Prevalence of Sarcopenia According to Different Definitions for Older Adults by Age Groups at Pretest, El Paso (n = 85)

Definition	60–69 (n = 53)	70–79 (n = 24)	80–89 (n = 8)	P-value for difference*
FNIH, n (%)	1	2	3	< 0.001
EWGSOP2 probable, n (%)	2	4	4	< 0.001

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. *All analyses are chi-square tests; $p < 0.01$ are in green text.

No significant difference was observed between men and women (both $p > 0.05$; see Table 5.10). However, non-significantly, there were more women than men presenting with sarcopenia (according to FNIH) or sarcopenia probable (according to EWGSOP2).

Table 5.10:

*Difference in Prevalence of Sarcopenia According to Different Definitions for Older Adults by Gender at Pretest (*n = *85), El Paso*

Definition	Men (n = 35)	Women (n = 50)	P-value for difference*
FNIH, n (%)	2 (2.4%)	4 (4.7%)	0.686
EWGSOP2 probable, n (%)	4 (4.7%)	6 (7.1%)	0.936

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. *All analyses are chi-square tests.

Also, non-significantly, sarcopenia was more common in Hispanics than in Caucasians, according to both definitions (both $p > 0.05$; see Table 5.11). One participant was African-American.

Table 5.11:

Difference in Prevalence of Sarcopenia According to Different Definitions for Older Adults by Ethnicity at Pretest (n = 85), El Paso

Definition	Caucasians (n = 50)	Hispanics (n = 34)	P-value for difference*
FNIH, n (%)	1 (1.2%)	5 (5.9%)	0.800
EWGSOP2 probable, n (%)	4 (4.7%)	6 (7.1%)	0.377

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. *All analyses are chi-square tests.

5.3 Sarcopenia components

Sarcopenia components of low muscle strength, low lean mass, and low physical performance were examined. In the Melbourne sample, while FNIH identified 9% of participants with low handgrip strength and 43% low lean mass (ALM/BMI), EWGSOP1 and EWGSOP2, detected 32% and 11% of participants having low handgrip strength; and 22% and 32% had low lean mass (ALM/h^2), respectively. Only 3% had low gait speed by both sarcopenia definitions (see Figure 5.3). In addition, based on the revised EWGSOP2, 10% had low chair stand and low SPPB. Poor TUG performance was observed in 2% and poor 400mW performance in 36% of the sample.

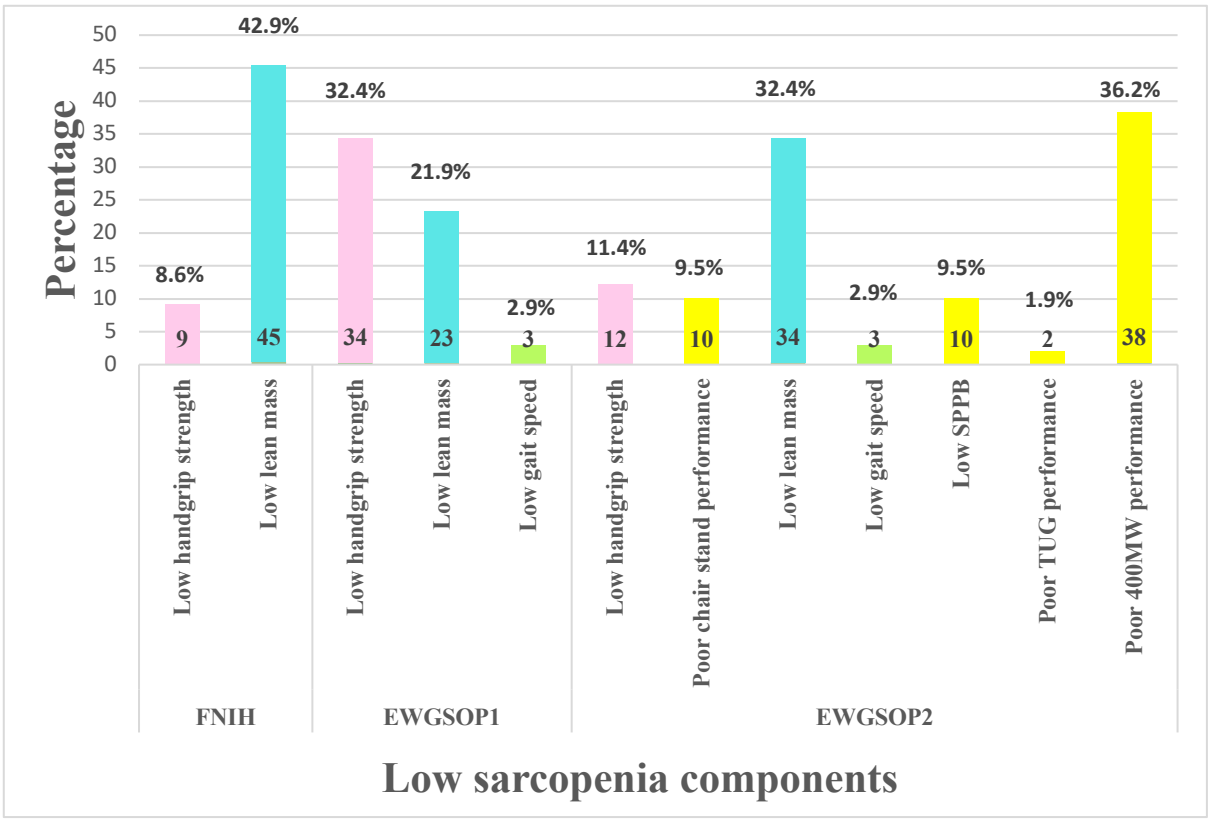

Figure 5.3. Low sarcopenia components according to different definitions at baseline, Melbourne. All data are frequency (%) or counts (n); FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People TUG: timed up and ago test; 400mW: 400-metre walk test.

In the El Paso sample at baseline (T1), according to FNIH, 12% of participants had low handgrip strength and 31% had low lean mass (ALM/BMI). For EWGSOP1 and EWGSOP2, 18% and 12% had low handgrip strength, respectively, but none had low lean mass (ALM/h^2), and only 6% had low gait speed by both EWGSOP definitions (see Figure 5.4).

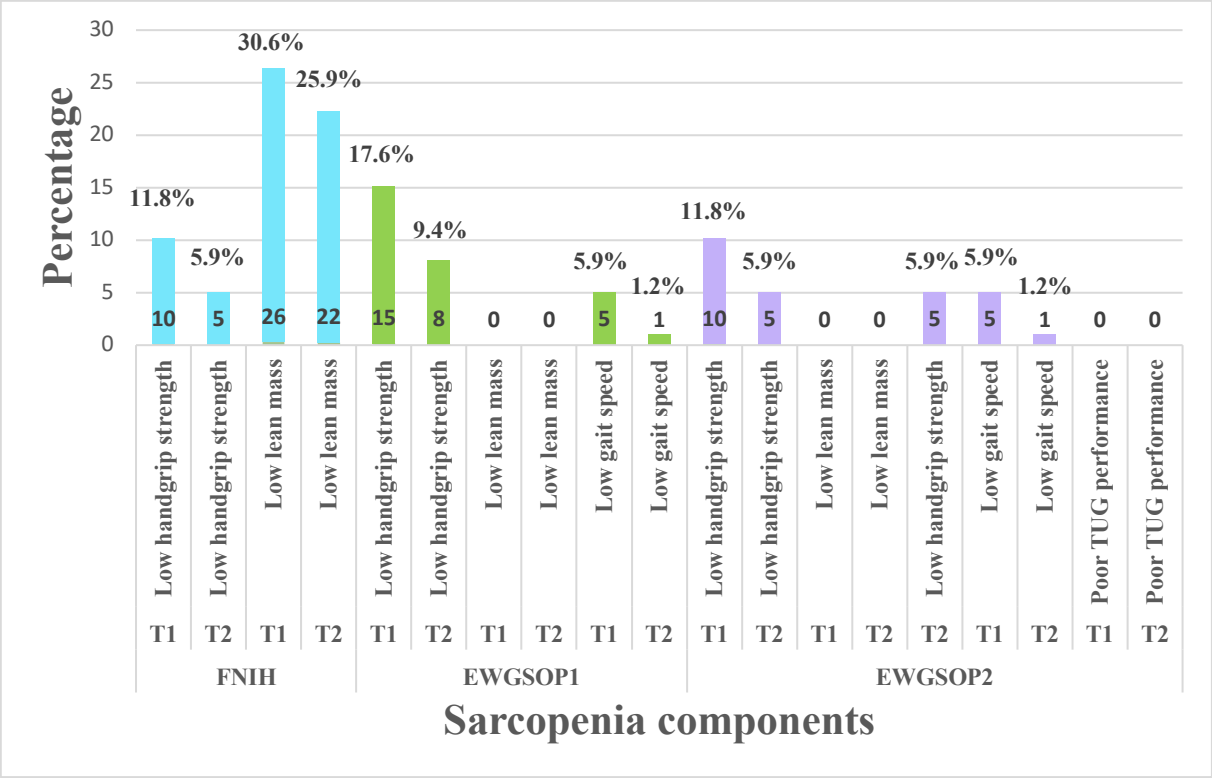

Figure 5.4. Low sarcopenia components according to different definitions at baseline, El Paso. All data are frequency (%) or counts (n); FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People TUG: timed up and ago test.

When comparing sarcopenia components at baseline between sites, chi-square tests revealed no significant difference in low handgrip strength ($p = 0.466$) and lean mass ($p = 0.082$) between sites according to FNIH (all $p > 0.05$). However, according to EWGSOP1, the Melbourne cohort showed significantly higher proportions of low muscle strength ($p = 0.021$) and mass ($p < 0.001$) compared to the El Paso sample, which had no low lean mass at all. Based on EWGSOP2, both samples were not significantly different for muscle strength ($p = 0.943$). Again, the Melbourne sample shows significantly less low lean mass ($p < 0.001$) than the El Paso sample. No significant difference was observed in low gait speed proportions according to EWGSOP1 and EWGSOP2 (both $p = 0.302$) and in poor TUG performance according to EWGSOP2 ($p = 0.201$). The same HRQoL assessment was performed via AQoL-4D for both samples. The El Paso sample at baseline had significantly higher HRQoL than the Melbourne sample ($p < 0.001$).

Paired-samples t-tests (see Table 5.12) were conducted for the El Paso cohort to evaluate the impact of the 16-week intervention as a whole (without examining ST and PT

groups separately) on sarcopenia components. Handgrip strength significantly increased from baseline (T1) to follow-up (T2). There was also a significant increase in ALM, and this trend was maintained when ALM was normalised for BMI and height^2. BMI significantly decreased post-test. Among physical performance variables, participants scored significantly higher on gait speed and lower on TUG, indicating that their gait speed and TUG were faster after the intervention.

Table 5.12:

Difference in Sarcopenia Components and HRQoL between Pre- and Post-Test for the Whole Sample, El Paso (n = 85)

Component	Paired difference (T2–T1)	P-value for difference*
Handgrip (kg)	3.71 (9.53)	0.001
ALM (kg)	0.67 (1.73)	0.001
BMI (kg/m^2)	–0.22 (0.91)	0.026
ALM/BMI (kg/m^2)	0.03 (0.05)	< 0.001
ALM/h^2 (kg/m^2)	0.38 (0.97)	0.001
Gait speed (m/s)	0.14 (0.16)	< 0.001
TUG (s)	–0.37 (0.57)	< 0.001
AQoL-4D (score)	0.03 (0.12)	0.025

All data are mean (SD). T1: pretest; T2: post-test; ALM: appendicular lean mass, BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; AQoL-4D: Assessment of Quality of Life; * All analyses are paired-samples t-tests; $p < 0.05$ are in green text.

Following 16-weeks of both ST and PT, the prevalence of low muscle strength, low lean mass and low physical performance reduced according to the three definitions in the El Paso sample (see Figure 5.4). According to FNIH, EWGSOP1 and EWGSOP2, low handgrip strength reduced by 50%. Low lean mass was only prevalent according to FNIH, which decreased by 15%. Low gait speed, which is a component of EWGSOP1 and EWGSOP2, reduced by 80%. No poor TUG performance, as part of EWGSOP2, was recorded either at pre- or post-test. McNemar's test showed a significant change in the proportion of subjects with low handgrip strength according to EWGSOP1, when compared with the proportion prior to the intervention ($p = 0.039$). Eight subjects no longer had low handgrip strength and seven remained low after training. No significant change in the proportion of participants with low handgrip strength was observed according to FNIH and EWGSOP2 ($p = 0.125$). Non-

significantly, according to FNIH and EWGSOP2, six participants no longer had low handgrip strength and four remained low after 16 weeks of training. According to both EWGSOP1 and EWGSOP2, non-significantly, one participant was observed to have lost strength and scored low on handgrip strength post-test. Further, there was no significant change in the proportion of participants with low lean mass according to FNIH ($p = 0.289$). Non-significantly, six participants no longer had low lean mass, 20 remained low after the intervention, and two became low on lean mass after training. There was a similar non-significant trend in gait speed according to EWGSOP1 and EWGSOP2 ($p = 0.289$). Non-significantly, four individuals improved and no longer tested as low on gait speed, and one remained low, at post-test.

The prevalence of normal weight increased by 10%, overweight decreased by 9%, but obesity increased by 3% (see Figure 5.5). McNemar's test showed no significant change in the proportion of obese participants v. non-obese participants, when compared with the proportion prior to the intervention ($p = 1.00$). Non-significantly, one obese participant was no longer obese and 31 remained obese after 16 weeks of training. However, one subject who was not obese at pretest was recorded as obese at post-test.

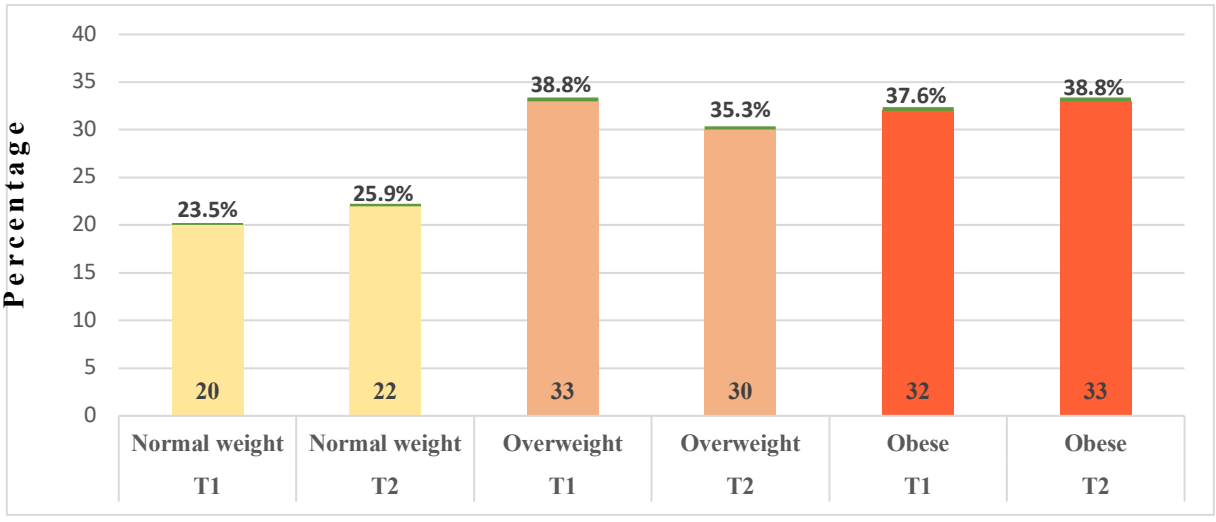

Figure 5.5 Prevalence of overweight and obesity at pre- and post-test, El Paso.
BMI: body mass index; normal weight: BMI ≥ 18; overweight: BMI ≥ 25–29.9; obese: BMI ≥ 30%. All data are counts (n) and frequency (%).

Independent sample t-tests were used to test differences for sarcopenia components, self-reported function, physical activity, HRQoL and nutrition between sarcopenic and non-sarcopenic subjects according to the three definitions. Since sarcopenia in El Paso was only detected with FNIH, comparison between sites was only made according to FNIH (see Table 5.13). In Melbourne, both muscle strength components (handgrip strength and chair stand)

were significantly lower in sarcopenic subjects compared to non-sarcopenic subjects. Lean mass, physical performance (gait speed, SPPB, TUG and 400mW), years trained, weekly gym visits and self-reported measures, were not significantly different between sarcopenic and non-sarcopenic subjects (all $p > 0.05$). In El Paso, handgrip strength was also significantly better in non-sarcopenic participants than in sarcopenic participants. ALM and ALM/h^2 were not significantly different between sarcopenic and non-sarcopenic participants (both $p > 0.05$). However, sarcopenic subjects had a significantly higher BMI and lower ALM/BMI than non-sarcopenic subjects. Regarding physical performance, non-sarcopenic subjects had significantly faster gait speed, but there was no significant difference in TUG between sarcopenic and non-sarcopenic participants.

Table 5.13:

Difference in Sarcopenia Components, Self-Reported Function, Physical Activity, HRQoL and Nutrition between Non-Sarcopenic and Sarcopenic Subjects according to FNIH, Melbourne

FNIH	Melbourne			El Paso		
Component	Non-sarcopenic subjects	Sarcopenic subjects	P-value for difference*	Non-sarcopenic subjects	Sarcopenic subjects	P-value for difference*
	n = 101	n = 4		n = 79	n = 6	
Handgrip (kg), mean (SD)	26.31 (8.12)	16.05 (5.97)	0.014	32.33 (12.89)	16.17 (5.42)	0.03
Chair stand (s), mean (SD)	10.18 (3.74)	6.21 (4.71)	0.042	-	-	-
ALM (kg), mean (SD)	18.90 (4.83)	16.82 (4.47)	0.400	19.16 (5.40)	15.62 (4.08)	0.121
BMI (kg/m^2), mean (SD)	28.24 (5.90)	30.21 (6.74)	0.517	28.31 (5.25)	33.97 (8.56)	0.017
ALM/BMI (kg/m^2), mean (SD)	0.68 (0.16)	0.56 (0.14)	0.140	0.69 (0.19)	0.47 (0.10)	0.002
ALM/h^2 (kg/m^2), mean (SD)	6.99 (1.30)	6.96 (1.35)	0.969	11.33 (2.68)	9.84 (2.19)	0.190
Gait speed (m/s), mean (SD)	1.32 (0.25)	1.14 (0.30)	0.161	1.51 (0.33)	0.86 (0.21)	<0.001
SPPB (score), median (IQR)	12.00 (1)	12.00 (4)	0.706	-	-	-
TUG (s), mean (SD)	8.47 (3.34)	12.40 (9.41)	0.465	4.71 (0.90)	7.76 (3.59)	0.092
400mW (min), mean (SD)	5.64 (1.55)	2.22 (2.56)	0.075	-	-	-
Years trained (yrs), mean (SD)	1.36 (0.61)	1.03 (0.69)	0.281	-	-	-
Weekly visits (days/week), mean (SD)	1.04 (0.51)	1.05 (0.29)	0.974	-	-	-
SARC-F (score), mean (SD)	1.68 (1.83)	2.50 (2.65)	0.391	-	-	-
	n = 97	n = 4				
PASE (score), mean (SD)	127.97 (57.29)	150.86 (101.17)	0.683	-	-	-
	n = 98	n = 4				
AQoL-4D (score), mean (SD)	0.69 (0.22)	0.72 (0.22)	0.782	0.83 (0.14)	0.66 (0.35)	0.277
	n = 86	n = 4				
AES protein (g), mean (SD)	101.46 (34.78)	108.40 (59.04)	0.706	-	-	-
AES energy (kj), mean (SD)	9227.45 (2769.82)	9726.25 (5610.95)	0.739	-	-	-
AES-ARFS (score), mean (SD)	35.19 (8.81)	38.50 (13.03)	0.473	-	-	-

HRQoL: health-related quality of life; ALM: appendicular lean mass; BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400-metre walk test; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls; PASE: Physical Activity Scale for the Elderly; AQoL-4D: Assessment of Quality of Life; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score. *All analyses are independent sample t-tests; $p < 0.05$ are in green text.

According to EWGSOP1 (see Table 5.14), handgrip strength was also significantly lower in sarcopenic participants than in non-sarcopenic participants. However, there was no significant difference in chair stand ($p = 0.316$). ALM and BMI were significantly lower in sarcopenic subjects than in non-sarcopenic subjects. This trend remained when ALM was normalised for height^2 but not for BMI ($p = 0.146$). Similar to FNIH, no significant difference was observed in physical performance, years trained, weekly gym visits and self-reported measures between sarcopenic and non-sarcopenic subjects (all $p > 0.05$).

Table 5.14:

Difference in Sarcopenia Components, Self-Reported Function, Physical Activity, HRQoL and Nutrition between Non-Sarcopenic and Sarcopenic Subjects According to EWGSOP1, Melbourne

EWGSOP1	Melbourne		
Component	Non-sarcopenic subjects	Sarcopenic subjects	P-value for difference*
	n = 101	n = 4	
Handgrip (kg), mean (SD)	26.89 (8.09)	17.66 (4.18)	0.012
Chair stand (s), mean (SD)	9.90 (3.81)	11.13 (4.01)	0.316
ALM (kg), mean (SD)	19.35 (4.72)	14.31 (2.96)	< 0.001
BMI (kg/m^2), mean (SD)	28.87 (5.95)	23.61 (2.47)	<0.001
ALM/BMI (kg/m^2), mean (SD)	0.68 (0.16)	0.61 (0.12)	0.146
ALM/h^2 (kg/m^2), mean (SD)	7.13 (1.28)	5.76 (0.72)	< 0.001
Gait speed (m/s), mean (SD)	1.32 (0.25)	1.24 (0.22)	0.295
SPPB (score), median (IQR)	12.00 (1)	11.00 (2)	0.781
TUG (s), mean (SD)	8.66 (3.89)	8.31 (1.61)	0.774
400mW (min), mean (SD)	5.45 (1.76)	6.07 (1.24)	0.260
Years trained (yrs), mean (SD)	1.33 (0.62)	1.49 (0.53)	0.413
Weekly visits (days/week), mean (SD)	1.05 (0.50)	1.01 (0.49)	0.820
SARC-F (score), mean (SD)	1.68 (1.83)	1.83 (2.19)	0.593
	n = 97	n = 4	
PASE (score), mean (SD)	130.76 (58.76)	113.47 (61.32)	0.361
	n = 98	n = 4	
AQoL-4D (score), mean (SD)	0.69 (0.21)	0.69 (0.28)	0.956
	n = 86	n = 4	
AES protein (g), mean (SD)	103.68 (35.92)	86.41 (31.47)	0.150
AES energy (kj), mean (SD)	9392.13 (2916.33)	8109.60 (2603.36)	0.189
AES-ARFS (score), mean (SD)	35.45 (9.21)	34.40 (6.96)	0.729

HRQoL: health-related quality of life; ALM: appendicular lean mass; BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400-metre walk test; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls; PASE: Physical Activity Scale for the Elderly; AQoL-4D: Assessment of Quality of Life; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score. *All analyses are independent sample t-tests; $p < 0.05$ are in green text.

According to EWGSOP2 (see Table 5.15), again handgrip strength was lower in sarcopenic individuals than in non-sarcopenic subjects, but there were no significant differences in chair stand time ($p = 0.059$). However, there was a significant moderate, negative association with gait speed and moderate, positive with TUG and ALM/BMI, and a strong, negative association with SPSS and positive with 400mW (see Table 5.16). ALM and BMI

were significantly lower in sarcopenic individuals. Again, this trend remained when ALM was adjusted for height^2 but not for BMI ($p = 0.388$). Similar to FNIH and EWGSOP1, physical performance and self-reported measures showed no significant difference between sarcopenic and non-sarcopenic individuals (all $p > 0.05$).

Table 5.15:

Difference in Sarcopenia Components, Self-Reported Function, Physical Activity, HRQoL and Nutrition between Non-Sarcopenic and Sarcopenic Subjects According to EWGSOP2, Melbourne

EWGSOP2	Melbourne		
Component	Non-sarcopenic subjects	Sarcopenic subjects	P-value for difference*
	n = 101	n = 4	
Handgrip (kg), mean (SD)	26.37 (8.08)	14.45 (2.91)	0.040
Chair stand (s), mean (SD)	9.89 (3.72)	13.58 (5.56)	0.059
ALM (kg), mean (SD)	19.02 (4.78)	13.73 (2.35)	0.030
BMI (kg/m^2), mean (SD)	28.54 (5.91)	22.68 (1.36)	< 0.001
ALM/BMI (kg/m^2), mean (SD)	0.68 (0.16)	0.61 (0.12)	0.388
ALM/h^2 (kg/m^2), mean (SD)	7.04 (1.29)	5.68 (0.59)	0.040
Gait speed (m/s), mean (SD)	1.31 (0.25)	1.22 (0.24)	0.443
SPPB (score), median (IQR)	12.00 (1)	10.50 (3)	0.291
TUG (s), mean (SD)	8.61 (3.78)	8.83 (1.80)	0.910
400mW (min), mean (SD)	5.48 (1.72)	6.35 (1.46)	0.324
Years trained (yrs), mean (SD)	1.34 (0.62)	1.69 (0.26)	0.067
Weekly visits (days/week), mean (SD)	1.04 (0.50)	1.15 (0.68)	0.662
SARC-F (score), mean (SD)	1.71 (1.89)	1.75 (0.96)	0.969
	n = 97	n = 4	
PASE (score), mean (SD)	128.29 (58.25)	142.96 (84.02)	0.628
	n = 98	n = 4	
AQoL-4D (score), mean (SD)	0.69 (0.22)	0.71 (0.13)	0.885
	n = 86	n = 4	
AES protein (g), mean (SD)	101.51 (36.28)	109.19 (8.70)	0.716
AES energy (kj), mean (SD)	9253.69 (2948.03)	9131.67 (163.27)	0.712
AES-ARFS (score), mean (SD)	35.34 (9.11)	35.00 (3)	0.948

HRQoL: health-related quality of life; ALM: appendicular lean mass; BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400-metre walk test; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls; PASE: Physical Activity Scale for the Elderly; AQoL-4D: Assessment of Quality of Life; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score. *All analyses are independent sample t-tests; $p < 0.05$ are in green text.

Spearman correlations explored associations among sarcopenia components between sites. Within the Uniting AgeWell gyms, there was a significant weak, negative association between the strength variables (handgrip strength and chair-stand time), indicating that almost 5% of the variance in handgrip strength was explained by chair stand performance (see Table 5.16). Handgrip showed a significant weak, positive association with gait speed, implying that

handgrip accounted for almost 6% of the variance in gait speed. However, handgrip was not significantly correlated with the remaining physical performance measures (i.e., TUG, SPPB or 400mW—all $p > 0.05$). In addition, there was a significant moderate, positive association between handgrip and ALM, indicating that almost 30% of the variance in handgrip strength was explained by ALM. These associations were maintained when ALM was normalised to BMI and height^2, implying that handgrip accounted for almost 26% and 17% of the variance in ALM/BMI and ALM/h^2, respectively. Further, the chair stand had a significant moderate, positive relationship with ALM/BMI, indicating that almost 5% of the variance in chair-stand time was explained by ALM/BMI, but not with ALM or ALM/h^2 (both $p > 0.05$). Also, ALM/BMI had a significant weak, positive association with ALM/h^2. Chair stand had a significant moderate, negative association with gait speed, implying that chair-stand time accounted for almost 21% of the variance in gait speed. It also had a moderate, positive association with TUG, indicating that almost 22% of the variance in chair-stand time was explained by TUG.

Additionally, there was a significant strong, negative association with SPPB and positive with 400mW, implying that chair-stand time accounted for almost 31% of the variance in SPPB and 400mW. Gait speed was significantly associated with all physical performance variables (all $p < 0.05$). Gait speed had a significant strong, positive correlation with SPPB score, indicating that nearly 38% of the variance in gait speed was explained by SPPB score and a strong negative correlation with TUG and 400mW, indicating that gait speed accounted for nearly 54% and 37% of the variance in TUG and 400mW, respectively. There was also a significant negative, strong relationship between SPPB and TUG, implying that almost 42% of the variance in SPPB was explained by TUG, and negative, moderate correlation with 400mW, indicating that almost 29% of the variance in SPBB was explained by 400mW. In addition, a strong positive correlation was observed between TUG and 400mW, implying that TUG accounted for nearly 26% of the variance in 400mW.

Table 5.16:

Associations for Self-Reported Function, Physical Activity, HRQoL and Nutrition with Sarcopenia Components, Melbourne

Component		Muscle strength		Lean mass			Physical performance			
		Handgrip (kg)	Chair stand (s)	ALM (kg)	ALM/BMI (kg/m^2)	ALM/h^2 (kg/m^2)	Gait speed (m/s)	SPPB (score)	TUG (s)	400mW (min)
SARC-F (score)	Spearman coefficient	–0.004	0.227*	0.194*	0.143	0.17	–0.427**	–0.507**	0.487**	0.368**
	p	0.967	0.02	0.047	0.144	0.083	< 0.001	< 0.001	< 0.001	< 0.001
	n	105	105	105	105	105	105	105	105	105
PASE (score)	Spearman coefficient	0.214*	–0.153	0.022	0.216*	–0.045	0.197*	0.319**	–0.235*	–0.210*
	p	0.032	0.126	0.824	0.03	0.655	0.048	0.001	0.018	0.035
	n	101	101	101	101	101	101	101	101	101
AQoL-4D (score)	Spearman coefficient	0.029	–0.201*	0.149	0.141	0.113	0.337**	0.308**	–0.396**	–0.272**
	p	0.774	0.043	0.136	0.156	0.257	0.001	0.002	< 0.001	0.006
	n	102	102	102	102	102	102	102	102	102
AES protein (g)	Spearman coefficient	0.123	0.037	0.232*	0.320**	0.179	0.171	–0.014	–0.002	–0.101
	p	0.25	0.726	0.028	0.002	0.091	0.107	0.899	0.984	0.343
	n	90	90	90	90	90	90	90	90	90
AES energy (kJ)	Spearman coefficient	0.168	0.03	0.250*	0.414**	0.197	0.112	–0.024	0.009	–0.029
	p	0.114	0.776	0.017	< 0.001	0.063	0.295	0.825	0.93	0.785
	n	90	90	90	90	90	90	90	90	90
AES-ARFS (score)	Spearman Coefficient	–0.083	–0.062	0.086	0.115	0.109	–0.006	–0.035	–0.045	–0.102
	p	0.436	0.559	0.42	0.28	0.305	0.958	0.743	0.67	0.34
	n	90	90	90	90	90	90	90	90	90
Handgrip (kg)	Spearman coefficient	1	–0.217*	0.545**	0.508**	0.416**	0.247*	0.178	–0.159	–0.187
	p	-	0.026	< 0.001	< 0.001	< 0.001	0.011	0.07	0.106	0.056
	n	105	105	105	105	105	105	105	105	105
Chair stand (s)	Spearman coefficient	–0.217*	1	0.028	–0.222*	0.019	–0.453**	–0.553**	0.469**	0.554**
	p	0.026	-	0.779	0.023	0.847	< 0.001	< 0.001	< 0.001	< 0.001
	n	105	105	105	105	105	105	105	105	105
ALM (kg)	Spearman coefficient	0.545**	0.028	1	0.568**	0.922**	0.013	–0.157	0.12	0.046
	p	0	0.779	-	< 0.001	< 0.001	0.895	0.109	0.221	0.64
	n	105	105	105	105	105	105	105	105	105
ALM/BMI (kg/m^2)	Spearman coefficient	0.508**	–0.222*	0.568**	1	0.316**	0.282**	0.043	–0.116	–0.146
	p	< 0.001	0.023	< 0.001	-	0.001	0.004	0.665	0.24	0.136
	n	105	105	105	105	105	105	105	105	105
ALM/H^2 (kg/m^2)	Spearman Coefficient	0.416**	0.019	0.922**	0.316**	1	–0.022	–0.117	0.124	0.023
	p	< 0.001	0.847	< 0.001	0.001	-	0.82	0.233	0.209	0.819
	n	105	105	105	105	105	105	105	105	105
Gait speed (m/s)	Spearman coefficient	0.247*	–0.453**	0.013	0.282**	–0.022	1	0.620**	–0.815**	–0.606**
	p	0.011	< 0.001	0.895	0.004	0.82	-	< 0.001	< 0.001	< 0.001
	n	105	105	105	105	105	105	105	105	105
SPPB (score)	Spearman coefficient	0.178	–0.553**	–0.157	0.043	–0.117	0.620**	1	–0.648**	–0.541**
	p	0.07	< 0.001	0.109	0.665	0.233	< 0.001	-	< 0.001	< 0.001
	n	105	105	105	105	105	105	105	105	105
TUG (s)	Spearman Coefficient	–0.159	0.469**	0.12	–0.116	0.124	–0.815**	–0.648**	1	0.640**
	p	0.106	< 0.001	0.221	0.24	0.209	< 0.001	< 0.001	-	< 0.001
	n	105	105	105	105	105	105	105	105	105
400mW (min)	Spearman coefficient	–0.187	0.554**	0.046	–0.146	0.023	–0.606**	–0.541**	0.640**	1
	p	0.056	< 0.001	0.64	0.136	0.819	< 0.001	< 0.001	< 0.001	-
	n	105	105	105	105	105	105	105	105	105

Component		Muscle strength		Lean mass			Physical performance			
		Handgrip (kg)	Chair stand (s)	ALM (kg)	ALM/BMI (kg/m^2)	ALM/h^2 (kg/m^2)	Gait speed (m/s)	SPPB (score)	TUG (s)	400mW (min)
Years trained (yrs)	Spearman coefficient	–0.056	0.276**	0.052	–0.068	0.039	–0.172	–0.058	0.189	0.307**
	p	0.57	0.004	0.599	0.491	0.693	0.079	0.555	0.054	0.001
	n	105	105	105	105	105	105	105	105	105
Weekly visits (days/week)	Spearman coefficient	–0.016	0.101	–0.034	–0.074	–0.036	–0.047	–0.214*	0.017	–0.012
	p	0.874	0.305	0.728	0.453	0.719	0.632	0.029	0.866	0.907
	n	105	105	105	105	105	105	105	105	105

HRQoL: health-related quality of life; ALM: appendicular lean mass; BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400mw: 400-metre walk test; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls; PASE: Physical Activity Scale for the Elderly; AQoL-4D: Assessment of Quality of Life; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score. All analyses are Spearman correlations. ** $p < 0.01$ (2-tailed); * $p < 0.05$ (2-tailed) are in green text.

Within El Paso sample, Spearman correlations (see Table 5.17), which examined associations among sarcopenia components before the intervention, showed a significant strong association between handgrip and ALM. These associations were maintained when ALM was normalised to either BMI or height^2. There was also a significant moderate, positive association for handgrip with gait speed and a negative weak association with TUG. Further, gait speed had a weak, positive correlation with ALM and ALM/h^2. It also had a positive moderate association with ALM/BMI. There was a negative moderate correlation between gait speed and TUG and a negative weak correlation between TUG and ALM/BMI.

Table 5.17:

Associations for Self-Reported HRQoL with Sarcopenia Components at Pretest, El Paso

Component		Muscle strength		Lean mass		Physical performance	
		Handgrip (kg)	ALM (kg)	ALM/BMI (kg/m^2)	ALM/h^2 (kg/m^2)	Gait speed (m/s)	TUG (s)
AQoL-4D (score)	Spearman coefficient	–0.028	–0.110	–0.001	–0.117	0.067	0.047
	p	0.799	0.315	0.994	0.288	0.540	0.670
	n	85	85	85	85	85	85
Handgrip (kg)	Spearman coefficient	1.000	0.798**	0.616**	0.778**	0.433**	–0.314**
	p	-	< 0.001	< 0.001	< 0.001	< 0.001	0.003
	n	85	85	85	85	85	85
ALM (kg)	Spearman coefficient	0.798**	1.000	0.773**	0.988**	0.386**	–0.140
	p	.000	-	< 0.001	< 0.001	< 0.001	0.200
	n	85	85	85	85	85	85
ALM/BMI (kg/m^2)	Spearman coefficient	0.616**	0.773**	1.000	0.739**	0.584**	–0.313**
	p	< 0.001	< 0.001	-	< 0.001	< 0.001	0.004
	n	85	85	85	85	85	85
ALM/H^2 (kg/m^2)	Spearman coefficient	0.778**	0.988**	0.739**	1.000	0.371**	–0.159
	p	< 0.001	< 0.001	< 0.001	-	< 0.001	0.146
	n	85	85	85	85	85	85
Gait speed (m/s)	Spearman coefficient	0.433**	0.386**	0.584**	0.371**	1.000	–0.544**
	p	< 0.001	< 0.001	< 0.001	< 0.001	-	<0.001
	n	85	85	85	85	85	85
TUG (s)	Spearman coefficient	–0.314**	–0.140	–0.313**	–0.159	–0.544**	1.000
	p	0.003	0.200	0.004	0.146	< 0.001	-
	n	85	85	85	85	85	85

HRQoL: health-related quality of life; ALM: appendicular lean mass; BMI: body mass index; TUG: timed up and go test; AQoL-4D: Assessment of Quality of Life; All analyses are Spearman correlations. ** $p < 0.01$ (2-tailed); * $p < 0.05$ (2-tailed) are in green text.

Changes in sarcopenia components and HRQoL were calculated to assess the impact of 16 weeks of training. Spearman correlations (see Table 5.18) generally revealed no associations between changes in individual sarcopenia components (all $p > 0.05$) except for associations between ALM and their normalised forms to BMI and height^2.

Table 5.18:

Associations for Change in Self-Reported HRQoL with Change in Sarcopenia Components between Pre- and Post-Test, El Paso

Component		Muscle strength		Lean mass		Physical performance	
		Handgrip (kg)	ALM (kg)	ALM/BMI (kg/m^2)	ALM/h^2 (kg/m^2)	Gait speed (m/s)	TUG (s)
AQoL-4D (score)	Spearman coefficient	0.004	0.094	0.035	0.088	0.057	–0.106
	p	0.974	0.394	0.748	0.422	0.604	0.334
	n	85	85	85	85	85	85
Handgrip (kg)	Spearman coefficient	1.000	0.148	0.130	0.145	0.144	0.061
	p	-	0.177	0.234	0.186	0.188	0.581
	n	85	85	85	85	85	85
ALM (kg)	Spearman coefficient	0.148	1.000	0.878**	0.996**	0.029	0.066
	p	0.177	-	< 0.001	< 0.001	0.790	0.550
	n	85	85	85	85	85	85
ALM/BMI (kg/m^2)	Spearman coefficient	0.130	.878**	1.000	0.872**	0.059	0.063
	p	0.234	< 0.001	-	< 0.001	0.593	0.569
	n	85	85	85	85	85	85
ALM/h^2 (kg/m^2)	Spearman coefficient	0.145	0.996**	0.872**	1.000	0.036	0.080
	p	0.186	< 0.001	< 0.001	-	0.741	0.466
	n	85	85	85	85	85	85
Gait speed (m/s)	Spearman coefficient	0.144	0.029	0.059	0.036	1.000	–0.134
	p	0.188	0.790	0.593	0.741	-	0.223
	n	85	85	85	85	85	85
TUG (s)	Spearman coefficient	0.061	0.066	0.063	0.080	–0.134	1.000
	p	0.581	0.550	0.569	0.466	0.223	-
	n	85	85	85	85	85	85

HRQoL: health-related quality of life; ALM: appendicular lean mass; BMI: body mass index; TUG: timed up and go test; AQoL-4D: Assessment of Quality of Life; All analyses are Spearman correlations. ** $p < 0.01$ (2-tailed); * $p < 0.05$ (2-tailed) are in green text.

Both studies had the same two hypotheses depending on the gym or training type. In addition, the Melbourne study examined associations for sarcopenia components with self-reported function, physical activity, and nutrition.

H1 (Melbourne): There is a significant difference between HUR and conventional gym training for sarcopenia prevalence and its components.

Chi-square tests (see Table 5.19) showed no significant difference between HUR and conventional gym groups for sarcopenia prevalence, according to FNIH, EWGSOP1, SARC-F, EWGSOP2 probable, confirmed or severe (all $p > 0.05$).

Table 5.19:

Prevalence of Sarcopenia According to Different Definitions for Older Adults Participating in HUR and Conventional Gym Training, Melbourne (n = 105)

Definition	HUR (n = 76)	Conventional (n = 29)	P-value for difference*
FNIH, n (%)	3 (3.9%)	1 (3.4%)	0.905
EWGSOP1, n (%)	7 (9.2%)	4 (13.8%)	0.493
SARC-F, n (%)	13 (17.1%)	1 (3.4%)	0.066
EWGSOP2 probable, n (%)	13 (17.1%)	6 (20.7%)	0.670
EWGSOP2 confirmed, n (%)	3 (3.9%)	1 (3.4%)	0.905
EWGSOP2 severe, n (%)	2 (2.6%)	1 (3.4%)	0.822

FNIH: Foundation for the National Institutes of Health sarcopenia project; EWGSOP: European Working Group on Sarcopenia in Older People; SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls. *All analyses are chi-square tests.

Regarding sarcopenia components, independent sample t-tests (see Table 5.20) showed no significant difference in any muscle strength component (handgrip and chair stand) between HUR and conventional gym groups (all $p > 0.05$). Concerning lean mass components, ALM/h^2 (used in EWGSOP1 and EWGSOP2 definitions) was significantly higher among HUR than among conventional gym participants. The HUR group had significantly higher BMI, indicating that it was more overweight (BMI $\geq$ 25) compared to the conventional group. However, there was no significant difference in ALM or ALM/BMI between groups (all $p > 0.05$). Among physical performance components, participants at the conventional gym had faster gait speed (m/s) and TUG time (s). No significant difference was observed in SPPB or 400mW between groups (both $p > 0.05$).

Table 5.20:

Comparison of Self-Reported Function, Physical Activity, HRQoL, Nutrition and Sarcopenia Components between HUR and Conventional Gym Training, Melbourne (n = 105)

Component	HUR (n = 76)	Conventional (n = 29)	P-value for difference*
SARC-F (score)	1.95 (2.05)	1.10 (1.05)	0.007
PASE (score)	131.30 (63.86)	122.34 (44.08)	0.422
AQoL-4D (score)	0.67 (0.22)	0.75 (0.20)	0.116
AES protein (g), mean (SD)	107.24 (38.13)	89.64 (26.41)	0.030
AES energy (kJ), mean (SD)	9656.81 (2906.45)	8348.00 (2716.05)	0.047
ARFS (score), mean (SD)	35.32 (9.56)	35.36 (7.63)	0.987
Handgrip (kg), mean (SD)	26.03 (8.48)	25.64 (7.78)	0.830
Chair stand (s), mean (SD)	10.42 (3.97)	9.03 (3.29)	0.097
ALM (kg), mean (SD)	19.33 (4.86)	17.48 (4.49)	0.077
BMI (kg/m^2), mean (SD)	29.24 (6.28)	25.90 (3.93)	0.002
ALM/BMI (kg/m^2), mean (SD)	0.67 (0.16)	0.68 (0.14)	0.937
ALM/h^2 (kg/m^2), mean (SD)	7.17 (1.33)	6.52 (1.09)	0.021
Gait speed (m/s), mean (SD)	1.28 (0.27)	1.38 (0.19)	0.034
SPPB (score), median (IQR)	11.50 (2)	12.00 (1)	0.076
TUG (s), mean (SD)	9.07 (4.25)	7.45 (1.06)	0.003
400mW (s), mean (SD)	5.56 (1.89)	5.39 (1.14)	0.649
Years trained (yrs), mean (SD)	1.31 (0.63)	1.45 (0.58)	0.302
Weekly visits (days/week), mean (SD)	1.05 (0.51)	1.03 (0.48)	0.857

SARC-F: sarcopenia screening tool assessing strength, assistance in walking, rising from a chair, climbing stairs and falls; PASE: Physical Activity Scale for the Elderly; AQoL-4D: Assessment of Quality of Life; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score. * All analyses are independent sample t-tests; ALM: appendicular lean mass, BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400mW: 400-metre walk test. * All analyses are independent sample t-tests; $p < 0.05$ are in green text.

In addition, chi-square tests showed that proportions of men and women were not significantly different between groups ($p = 0.600$). Independent sample t-tests (see Table 5.20) also revealed that HUR gym participants were not significantly different from the conventional gym participants, either by years trained or weekly visits (both $p > 0.05$). On average, participants trained at both gyms for over a year, visiting the gyms about once a week. The analysis revealed that chair stand and 400mW had a significant weak, positive association with

years trained, indicating that almost 8% and 9% in the variance in years trained was associated with chair stand and 400mW, respectively. There was also a significant weak, negative correlation between weekly gym visits and SPPB. To explain the negative trend, one-way between-groups ANOVA test was conducted to explore the impact of years trained at the gym and weekly gym visits on sarcopenia components (see Table 5.21). The results show no significant difference in years trained at the gym or weekly gym visits for the three age groups (all $p > 0.05$). However, there was a non-significant trend for participants in the 70–79 age group to have trained the longest (i.e., nearly 1.5 years and for participants in the oldest age group 80–83 to have attended the gym most—slightly more than once a week compared to other age groups).

Table 5.21:

Difference between Three Age Groups by Years Trained and Weekly Gym Visits, Melbourne (n = 105)

Training frequency	60–69 (n = 12)	70–79 (n = 54)	80–83 (n = 39)	P-value for difference*
Years trained (yrs)	1.09 (0.69)	1.41 (0.57)	1.35 (0.64)	0.261
Weekly visits (days/week)	1.04 (0.36)	0.97 (0.43)	1.14 (0.61)	0.309

All data are mean (SD). *All analyses are one-way between-groups ANOVA.

H1 (El Paso): There is a significant difference between strength training and power training for sarcopenia prevalence and its components in older adults.

Due to the low prevalence of sarcopenia pretest, only changes in its components between ST and PT were explored when comparing pretest with post-test. Repeated measures ANOVA (see Table 5.22) showed no significant change in difference for sarcopenia components between ST and PT over time (all $p > 0.05$). While the ST group saw significant improvement in muscle strength, mass (absolute and normalised components) and function (all $p < 0.05$), the PT group also recorded a significant improvement in muscle strength and function (all $p < 0.05$) but not lean mass over time ($p > 0.05$).

Table 5.22:

Sarcopenia Components and HRQoL of the Strength Training and Power/Agility Training Groups at Pre- and Post-Test, El Paso (n = 85)

Component	ST (n = 56)		PT (n = 29)	
	Pretest	Post-test	Pretest	Post-test
Handgrip (kg)	33.48 (14.39)	37.66 (17.72) *	26.76 (9.07)	29.55 (9.43) *
ALM (kg)	19.42 (5.45)	20.31 (5.97) *	17.91 (5.18)	18.15 (4.96)
BMI (kg/m^2)	29.24 (6.36)	28.91 (6.00) *	27.68 (3.90)	27.68 (3.86)
ALM/BMI (kg/m^2)	0.68 (0.20)	0.71 (0.20) *	0.65 (0.18)	0.66 (0.18)
ALM/h^2 (kg/m^2)	11.46 (2.71)	11.96 (2.93) *	10.77 (2.55)	10.92 (2.42)
Gait speed (m/s)	1.49 (0.36)	1.62 (0.30) *	1.42 (0.37)	1.58 (0.35) *
TUG (s)	4.76 (1.15)	4.43 (0.91) *	5.23 (1.91)	4.79 (1.95) *
AQoL-4D (score)	0.81 (0.17)	0.86 (0.11) *	0.83 (0.15)	0.84 (0.14)

All data are mean (SD).ST: strength training; PT: power/agility training; ALM: appendicular lean mass, BMI: body mass index; TUG: timed up and go test; AQoL-4D: Assessment of Quality of Life Significantly different from pretest. *Significantly different from pretest (in green text). All analyses are repeated measures ANOVA.

To observe the change for sarcopenia components between training groups, independent samples t-tests were conducted (see Table 5.23). ALM/BMI approached significance ($p = 0.051$), indicating that the ST group had an increase in ALM/BMI (used in FNIH) relative to the PT group. There was a non-significant trend for ST participants to have higher ALM, BMI and ALM/h^2 than PT participants. Non-significantly, while the ST group performed better in handgrip strength, the PT group had a faster gait speed and TUG.

Table 5.23:

Difference in Change in Sarcopenia Components and HRQoL between Strength Training and Power/Agility Training between Pre- and Post-Test, El Paso (n = 85)

Component	ST (n = 56)	PT (n = 29)	P-value for difference*
Handgrip (kg)	4.18 (11.31)	2.79 (4.45)	0.528
ALM (kg)	0.89 (1.98)	0.24 (1.00)	0.100
BMI (kg/m^2)	–0.34 (0.97)	–0.01 (0.73)	0.111
ALM/BMI (kg/m^2)	0.03 (0.06)	0.01 (0.04)	0.051
ALM/h^2 (kg/m^2)	0.50 (1.10)	0.15 (0.61)	0.119
Gait speed (m/s)	0.13 (0.15)	0.16 (0.17)	0.381
TUG (s)	–0.33 (0.60)	–0.44 (0.51)	0.422
AQoL-4D (score)	0.04 (0.12)	0.00 (0.11)	0.140

All data are mean (SD). ST: strength training; PT: power/agility training; ALM: appendicular lean mass, BMI: body mass index; TUG: timed up and go test; AQoL-4D: Assessment of Quality of Life. * All analyses are independent sample t-tests.

Apart from sarcopenia components, this study also analysed effects of the intervention on body composition and other fitness measures in the El Paso cohort. Repeated measures ANOVA (see Table 5.24). showed that following 16 weeks of training, both groups had significant improvements in strength (both right and left hand separately), muscular endurance (30-second arm curl and chair-stand tests), gait speed (flat ground walking speed), upper-body power (standing and seated medicine ball throws) and aerobic endurance (six-minute walk). Only the PT group showed significant improvement on lower-body power (vertical jump), while only the ST group improved significantly on the back-leg strength (dynamometer) test. The ST group also demonstrated significant improvements in bone mineral density (BMD) after training, while total lean mass increased for both ST and PT groups. No significant fitness improvement differences were observed between the groups for any measures (all $p > 0.05$).

Table 5.24:

Fitness and DEXA Measurements of the Strength Training and Power/Agility Training Groups at Pre- and Post-Test, El Paso (n = 85)

Component	ST		PT	
	Pretest	Post-test	Pretest	Post-test
Left leg balance (points)	6.09 (1.48)	6.36 (1.12)	6.00 (1.36)	6.14 (1.03)
Right leg balance (points)	6.12 (1.59)	6.45 (1.06)	5.69 (1.58)	5.93 (1.41)
Two-leg vert. jump (inch)	9.43 (3.47)	9.83 (3.66)	8.06 (3.43)	8.61 (3.62) *
One-leg vert. jump (inch)	5.27 (2.85)	6.10 (2.82)	4.88 (2.63)	5.36 (2.83)
Seated m. ball throw (cm)	313.68 (60.95)	328.95 (56.33) *	298.48 (53.24)	309.07 (57.4) *
Stand m. ball throw (cm)	471.95 (111.95)	508.87 (126.91) *	422.76 (112.51)	443.10 (116.06) *
Speed walk (sec)	8.40 (1.95)	7.64 (1.68) *	9.74 (3.60)	8.60 (2.74) *
Handgrip left (kg)	29.45 (11.65)	33.07 (13.91) *	24.48 (9.34)	26.41 (8.37) *
Handgrip right (kg)	32.51 (15.26)	36.31 (18.33) *	25.17 (8.37)	28.45 (9.01) *
Back-leg strength (kg)	109.18 (51.85)	117.11 (50.46) *	88.21 (40.81)	92.38 (37.06)
30-sec chair stand (reps)	16.57 (6.00)	19.21 (6.17) *	14.62 (6.28)	17.66 (6.98) *
30-sec arm curl (reps)	23.77 (4.89)	27.05 (4.64) *	22.66 (4.56)	26.17 (5.18) *
6-min walk (miles)	0.33 (0.08)	0.36 (0.07) *	0.32 (0.08)	0.35 (0.08) *
Ruler drop (inch)	8.28 (2.12)	8.08 (1.88)	9.44 (3.53)	8.92 (1.66)
BMD (g/cm²)	1.22 (0.15)	1.23 (0.15) *	1.19 (0.12)	1.20 (0.13)
Total lean mass (kg)	45.62 (12.37)	46.38 (12.75) *	41.51 (10.10)	42.03 (10.39) *

All data are mean (SD). ST: strength training; PT: power/agility training; BMD: bone mineral density* Significantly different from pretest (in green text). All analyses are repeated measures ANOVA.

H2 (Melbourne): Components of sarcopenia are associated with poorer HRQoL in older adults participating in exercise programs.

Spearman correlations (see Table 5.16) revealed a significant weak, negative association between chair stand and HRQoL, indicating that nearly 5% of the variance in chair stand was explained by HRQoL. No significant relationship was observed between handgrip and HRQoL ($p = 0.774$). There was a weak, positive correlation for gait speed and SPPB with HRQoL, indicating that almost 11% and 9% of the variance in gait speed and SPPB were explained by HRQoL, respectively. A significant moderate, negative association occurred between TUG and HRQoL, implying that nearly 16% of the variance in TUG was explained by HRQoL. There was

also a significant weak, negative association for 400mW with HRQoL, indicating that almost 7% of the variance in 400mW was explained by HRQoL. None of the lean mass variables were associated with HRQoL (all $p > 0.05$). Independent sample t-tests (see Table 5.20) showed no significant differences for HRQoL between the groups ($p > 0.05$). Although the findings did not reach statistical significance, the conventional group scored higher in HRQoL than the HUR group ($p = 0.116$).

H2 (El Paso): Components of sarcopenia are associated with poorer HRQoL in older adults participating in exercise programs.

Spearman correlations (see Table 5.18) revealed no significant association for the change in sarcopenia components with the change in HRQoL when comparing pretest with post-test. HRQoL significantly increased in the ST group compared to pretest, but not in the PT group (see Table 5.22).

H3 (Melbourne): Components of sarcopenia are associated with poorer self-reported function in older adults participating in exercise programs.

Regarding strength variables, Spearman correlations (see Table 5.16) showed a significant weak, positive correlation between chair stand and SARC-F, indicating that almost 5% of the variance in chair-stand performance was explained by SARC-F score. However, there was no significant association between handgrip and SARC-F ($p = 0.967$). In terms of lean mass variables, there was a significant weak, positive correlation between ALM and SARC-F, suggesting that almost 10% of the variance in ALM was explained by SARC-F score. However, these associations became non-significant when ALM was normalised to either BMI or height^2 (both $p > 0.05$). Among physical performance variables, there was a significant moderate, negative correlation for gait speed and SPPB with SARC-F, indicating that 18% and 26% of the variance in gait speed and SPPB, respectively, were explained by SARC-F score. A moderate, positive correlation was observed for TUG and 400mW with SARC-F, indicating that nearly 24% and 14% of the variance in TUG and 400mW, respectively, were explained by SARC-F score. Independent sample t-tests (see Table 5.20) revealed that the conventional group scored significantly lower on SARC-F, implying a better self-reported physical function than the HUR gym group.

H4 (Melbourne): Components of sarcopenia are associated with lower self-reported physical activity in older adults participating in exercise programs.

Spearman correlations (see Table 5.16) revealed PASE had a significant weak, positive association with handgrip, indicating nearly 4% of the variance in handgrip was explained by PASE score. However, there was no significant relationship between PASE and chair stand ($p = 0.126$). A

significant association was observed for ALM/BMI with PASE, implying that nearly 5% of the variance in ALM/BMI was explained by PASE score. However, there was no significant association for ALM or its normalised form for height with PASE (both $p > 0.05$). Further, gait speed had a significant weak, positive association with PASE, indicating that nearly 4% of the variance in gait speed was explained by PASE score. There was also a significant, weak positive correlation between SPPB and PASE, suggesting that almost 10% of the variance in SPPB was explained by PASE score. A weak negative relationship was observed between TUG and PASE, which means nearly 6% of the variance in TUG was explained by PASE score; 400mW had a significant weak, negative association with PASE, implying that almost 4% of the variance in 400mW was explained by PASE score. Independent sample t-tests (see Table 5.20) showed no significant differences for PASE between the groups ($p > 0.05$).

H5 (Melbourne): Components of sarcopenia are associated with self-reported nutrition in older adults participating in exercise programs.

Within the AES survey, protein intake, energy intake and ARFS were explored. Spearman correlations (see Table 5.16) showed a significant weak, positive association for ALM and ALM/BMI with protein intake, implying that nearly 5% and 10% of the variance in ALM and ALM/BMI were explained by protein intake, respectively. However, the correlation lost its significance when ALM was normalised to height^2 ($p = 0.179$). A similar trend was observed for energy intake. There was a significant weak, positive association between ALM and energy intake, suggesting that almost 6% of the variance in ALM was explained by energy intake, and a moderate association between ALM/BMI and energy intake, implying that nearly 17% of the variance in ALM/BMI was explained by energy intake. However, the association lost its significance when ALM was normalised to height^2 ($p = 0.197$). ARFS was not associated with any of the sarcopenia components (all $p > 0.05$). Independent sample t-tests (see Table 5.20) revealed that HUR group had significantly higher self-reported protein and energy intakes compared to the conventional group. However, no significant difference was observed in ARFS between groups ($p > 0.05$).

Chapter 6: Discussion

This project assessed prevalence of sarcopenia in community-dwelling older adults participating in exercise programs using three current operational definitions. In addition to associations for sarcopenia components with HRQoL, the Melbourne study explored associations with self-reported function, physical activity and nutrition. The observed prevalence of sarcopenia in older adults participating in supervised exercise programs was lower than that reported in the general community (7.9% and 31.9% according to FNIH and EWGSOP) (Schaap, van Schoor, Lips, & Visser, 2017), aged care (31.4% and 32.5%) (Zeng et al., 2018) or hospitals (24% and 36%) (Volpato, Bianchi, & Landi, 2018) and also varied according to definition (Beaudart et al., 2018; Schaap et al., 2017). The Melbourne and El Paso cohorts were community-dwelling older adults independent enough to travel to the gyms where the studies were conducted; thus, it is unsurprising that sarcopenia prevalence was low in both groups.

The low prevalence of sarcopenia (ranging from 3.8–10.5%) is potentially also influenced by the fact that the Melbourne group was an exercising population, consistent with the idea that resistance training can prevent/reverse sarcopenia (Beaudart et al., 2016; Frost et al., 2016; Liu & Latham, 2009; Morley, 2018; Skelton et al., 1995; Taaffe, 2006; Tschopp et al., 2011; Vikberg et al., 2019). While the Melbourne cohort, which were lightly and voluntary physically active, underwent resistance training for one hour once a week for about a year on average in community-dwelling settings, the El Paso group was inactive and sedentary before they were assigned to ST and PT groups for two 90-minute sessions for 16 weeks in laboratory settings. The El Paso group was fit to begin with, yet they sarcopenia prevalence slightly differed from the Melbourne group. Although the Melbourne cohort was significantly older, they reported a lower prevalence of sarcopenia (3.8%) than the El Paso group (7.1%) according to FNIH. This may be due to the fact that El Paso participants were significantly taller and non-significantly heavier than Melbourne participants at baseline, which could affect lean mass (ALM/BMI). Conversely, sarcopenia probable (based on muscle strength) according to EWGSOP2 was more prevalent in the Melbourne group (18.1%) than the El Paso group (11.8%), which may be explained by the fact that El Paso subjects had significantly better handgrip strength, thus lower sarcopenia probable than among Melbourne subjects at baseline (see Table 5.1).

The Melbourne study showed that no participant was confirmed with sarcopenia according to all definitions. As such, if the definitions are grouped together, prevalence could

be as high as 20% (18.4%), suggesting sarcopenia may be common, even among people undertaking exercise training. This highlights the importance of early identification and clinical monitoring to avoid the dire consequences of sarcopenia, regardless of the diagnosis definition used. Given that there were no significant differences between HUR and conventional gyms for sarcopenia prevalence, it can be inferred that exercise training at both types of gyms operated by Uniting AgeWell may be equally effective in influencing sarcopenia prevalence (and/or sarcopenia components).

The Melbourne study finding supports prior literature indicating that sarcopenia prevalence is lower when using the FNIH compared to EWGSOP definitions (Dam et al., 2014; Schaap et al., 2017). Potentially, more people will be diagnosed with sarcopenia using EWGSOP1 than FNIH since the criteria for low handgrip (< 30 v. < 26 kg in men and similar difference in women) are less conservative and, if gait speed is low, people without low handgrip strength may still be assessed as sarcopenic (Scott et al., 2017). Conversely, the El Paso study showed a higher prevalence of sarcopenia according to FNIH, since no participant fulfilled the criteria for low lean mass (ALM/h^2) according to EWGSOP1 and EWGSOP2. Training contributed to a non-significant reduction of sarcopenia by 44% and 50% according to FNIH and EWGSOP2 sarcopenia probable, respectively. The non-significance is likely due to the overall low numbers with sarcopenia in the first place (~10%), as clearly, reductions in sarcopenia prevalence of 50% would be highly clinically significant. Variations in sarcopenia prevalence depending on the applied diagnostic criteria could lead to negative public health outcomes—over- or underestimation of the sarcopenia prevalence could affect therapeutic or preventative interventions by increasing risk of treating a patient without sarcopenia and depriving a patient with sarcopenia of necessary treatment (Beaudart et al., 2015). Failure to treat a person because of undiagnosed sarcopenia would be more serious than referring a patient without sarcopenia for treatment given the primary treatment strategies involve exercise and/or nutrition. A universally accepted consensus on sarcopenia is necessary for consistent diagnosis and implementation in clinical settings (Beaudart et al., 2015).

Currently, few studies have explored the prevalence of sarcopenia according to EWGSOP2 owing to its recent publication (Locquet, Beaudart, Petermans, Reginster & Bruyère, 2019; Su et al., 2019). Due to changes to the algorithm from EWGSOP1 (see Figure 3.2) and lower cut-off points (Cruz-Jentoft et al., 2018), sarcopenia prevalence in the Melbourne sample was lower for EWGSOP2 than for EWGSOP1, which supports recent findings that the use of EWGSOP2 will potentially underestimate sarcopenia prevalence compared to EWGSOP1 (Locquet et al., 2019). Consequently, public spending on sarcopenia

would be greater if EWGSOP1 guidelines are followed. The consensus from the ANZSSFR recommends to continue working with EWGSOP1 in Australia and New Zealand (Zanker et al., 2019), at least until Australia has its own data-verified cut-points. This approach was supported further when the initial screening tool SARC-F in EWGSOP2 was unable to reliably predict sarcopenia cases if the complete algorithm was followed, meaning many cases would fail to be identified clinically if EWGSOP2 was adopted.

Since EWGSOP2 offers many measurement options for each sarcopenia component, discrepancies in prevalence estimates depending on the option applied are expected. Phu et al. (2019) demonstrated that sarcopenia prevalence varied depending on EWGSOP2 measures, stating that highest prevalence was reported when using chair stand for muscle strength and lowest when using TUG for physical performance). In the Melbourne study, muscle strength was assessed by handgrip strength. However, sarcopenia prevalence would be lower if it was assessed by chair stand, as poor chair-stand performance was less common than poor handgrip strength in the Melbourne cohort. Gait speed was used to assess physical performance. If TUG had been used, sarcopenia prevalence would be lower. However, if 400mW was assessed, it would be higher due to highest proportions of poor 400mW performance across the sample. This demonstrates the inconsistency of sarcopenia prevalence assessment, even within the same definition.

The current data showed that people who trained for a longer period performed worse in chair stand and 400mW, and those who visited gyms more often performed worse in SPPB, which appears counter to expectations There was a non-significant trend for participants in the 70–79 age group to have trained the longest and for participants in the oldest age group 80–83 to have attended the gym most compared to other age groups. Possible factors affecting results for 80–83-year-olds could be the prescription of more regular gym sessions for those perceived to be in greater need. Thus, for health reasons, or because they find the gym a more accessible exercise option offering social interaction (Boulton-Lewis, Buys, Lewis, Vine & Dendle, 2019), pleasure (Phoenix & Orr, 2014) or promoting exercise and safety to people with chronic diseases and health conditions (American College of Sports Medicine, 2014), older people may visit the gym more often.

Both studies support the concept that sarcopenia increases with age (Rosenberg, 1989, 2011) and while muscles can continue to adapt to exercise training, loss of mass and/or function cannot be prevented entirely. In the Melbourne cohort, sarcopenia was not observed in the youngest age group (60–69-year-olds) but was present in 70–79-year-olds. This was similar across FNIH and EWGSOP2 sarcopenia probable. However, in the El Paso cohort, sarcopenia was recorded in the youngest age group and increased in 70–79-year-olds according to both

definitions. Due to low sarcopenia prevalence in both studies, components of sarcopenia (muscle strength, mass and physical performance) were analysed. Both Melbourne and El Paso studies had low proportions of low handgrip strength (under 12%) but high proportions (over 30%) of low lean mass (ALM/BMI) according to FNIH. Less than 6% participants had low gait speed and poor TUG performance, implying that most participants did short distance walk and TUG with ease, which were conducted at normal speed. However, over 30% Melbourne participants had poor 400mW performance (which was performed as fast as possible), suggesting that even for older adults attending gym programs, cardiovascular fitness can be challenging. The results indicate that assessing sarcopenia components are important, as low muscle strength, mass and physical performance are essential risk factors for frailty, falls and mortality (Hars et al., 2016; Landi et al., 2011, 2012, 2016; Sarodnik et al., 2018; Skelton et al., 1994; Suetta et al., 2019). A current study using data from the WHO from China, Mexico, Ghana, India, Russia and South Africa showed that low handgrip strength and gait speed and the combination of both are associated with higher functional disability levels in older adults. This indicates that these tests can potentially assess negative health outcomes (Brennan-Olsen et al., 2019).

Melbourne's conventional training group had significantly faster gait speed and TUG than HUR gym participants. This may be attributable to differences in the exercise programs; the conventional gym includes dynamic exercises (e.g., using medicine balls and jumping), which may be more effective for improving mobility than training with resistance equipment. Similarly, the El Paso PT group used more dynamic activities (medicine ball chest pass throw and vertical jump) than the ST group. Although there were no significant differences between the groups, while the ST group performed better for upper-body strength (handgrip), the PT group was better for lower-leg function (gait speed and TUG). Past research shows that exercises should be dynamic rather than static, targeting major muscle groups applying both concentric (lifting/pushing) and eccentric (slow lowering) movements and prioritising lower-extremity muscle groups (knee/hip extensors, knee flexors, dorsi- and plantarflexors) since they are important for balance, mobility and falls prevention (Taaffe, 2006). Current training guidelines recommend high-velocity training, as it is associated with generating force quickly and improving the ability to perform ADL (American College of Sports Medicine, 2014; Anthony & Brown, 2016).

Although not significantly different, both dynamic and isometric resistance training using TheraBands for 16 weeks improved physical function and reduced knee joint pain of patients with knee osteoarthritis compared to a control group (Topp, Woolley, Hornyak III, Khuder & Kahaleh, 2002). In addition, dynamic exercises involving jumping led to increased muscle strength and balance in older adults following four weeks of training (Park, Cho & Lee, 2012).

When using high-speed power training including muscle power (walking speed, counter movement jump and ball throw) and functional tests (chair stand and TUG tests) over 12 weeks, older women in the experiment group significantly increased dynamic and isometric strength performance, muscle power and physical function as opposed to a control group. This implies that high-speed power training may be a more effective strategy for maintaining functional independence and QoL (Pereira et al., 2012). This suggests that adding extra power exercises, including jumping and medicine ball throws, can elicit more improvements in lower-extremity function.

In the El Paso study, while the ST group significantly improved in muscle strength, mass (absolute and normalised values) and function, the PT group also significantly improved in muscle strength and function, but not in lean mass components in community-dwelling older adults. Strength and power training can benefit muscle mass and function (Balachandran et al., 2017; Bean et al., 2003, 2004; Cadore & Izquierdo, 2018; Caserotti et al., 2008; Chan et al., 2018; Fiatarone et al., 1990; Liu & Latham, 2009; Sayers et al., 2016; Tschopp et al., 2011; Wallerstein et al., 2012). However, power training did not significantly contribute to increased lean mass over time. This could be due to the more dynamic nature of power training, in which less force is applied at higher velocities (with peak power occurring at approximately one-third of peak isometric force). Muscle mass gains are associated with high-force contractions, and are more likely to occur in strength training involving high-weight, slower concentric contactions. Thus, it is likely that the strength training increased lean mass in the 16 weeks of training, but the power training did not. However, both exercises would have been able to increase muscle power, albeit over differing velocities. This is important, as extensive research demonstrates that muscle power is a greater predictor of physical function than muscle strength in older adults (Bean et al., 2003; Hruda et al., 2003; Marsh et al., 2009; Miszko et al., 2003; Reid & Fielding, 2012; Rice & Keogh, 2009) and declines faster than muscle strength with age (Bean et al., 2003; Chodzko-Zajko et al., 2009; Izquierdo et al., 1999; Skelton et al., 1994; Skelton et al., 1995; Suetta et al., 2019). The El Paso study did not identify any significant difference between ST and PT groups for components of sarcopenia following the intervention, implying that both strength and power/agility training contributed to improved sarcopenia components.

Due to low sarcopenia prevalence in community-dwelling older adults in Melbourne and El Paso, it can be inferred that resistance training using HUR and conventional gyms operated by Uniting AgeWell, and strength and power/agility training offered at the University of Texas at El Paso, may be an effective intervention for the prevention of sarcopenia. Since strength training significantly contributed to muscle strength, mass, function and HRQoL, and

power/agility training only to muscle strength and function in older adults, it can be concluded that strength training was more effective than power/agility training. However, due to missing post-data in the Melbourne study, effects of resistance training on sarcopenia and its components over time could not be assessed. Even with 6-month post data available, it would not be advisable to judge whether resistance training is more effective than strength or power/agility training since the duration of intervention, intensity and frequency varied between these two studies.

Apart from sarcopenia components, this study also analysed effects of the intervention on other body composition and fitness measures in community-dwelling older adults in the El Paso region. Strength training alone improved power, speed, endurance and agility measures. Similarly, power/agility training delivered strength and muscular endurance improvements. One key difference was observed in the lower body, as strength training elicited greater back-leg strength improvement, whereas power training elicited greater vertical jump improvement. These overall findings support systematic reviews, indicating that strength training improves muscle strength and function, and power training improves power and function in older adults. However, recommendations on most effective strength and power training to specifically prevent sarcopenia are needed (Ayvat, Kilinc & Kirdi, 2017; Seguin & Nelson, 2003).

Limited studies have explored associations of sarcopenia components according to EWGSOP2 with self-reported function (via SARC-F), physical activity (via PASE), HRQoL (via AQoL-4D) and nutrition (via AES) in older adults (Su et al., 2019). Melbourne study findings show that although SARC-F was not significantly associated with sarcopenia prevalence according to different definitions, it was significantly associated with sarcopenia components including muscle strength (chair stand but not handgrip), lean mass (ALM) and physical performance (gait speed, SPPB, TUG and 400mW). SARC-F was designed to screen for sarcopenia (Malmstrom et al., 2016; Malmstrom & Morley, 2013; Morley & Malmstrom, 2014; Rolland et al., 2017; Woo et al., 2014; Wu et al., 2016). While SARC-F may detect severe cases (Cruz-Jentoft et al., 2018), in this study, SARC-F predicted one case for FNIH and EWGSOP1, four cases in EWGSOP2 sarcopenia probable but none with EWGSOP1 sarcopenia severe or EWGSOP2 sarcopenia confirmed or severe. SARC-F was not significantly associated with handgrip strength. Handgrip strength has functional importance in ADL, such as opening containers, lifting weights, using tools or holding handrails when ascending stairs (Skelton et al., 1994). Thus, a lack of association may be considered surprising. Further, handgrip strength is a key component of all three definitions and has also been correlated with a number of performance measures, including the TUG test (Pratama & Setiati,

2018) and knee extension (Bohannon, Magasi, Bubela, Wang & Gershon, 2012). Handgrip strength is also significantly associated with BMD in older women (Marin, Pedrosa, Moreira-Pfrimer, Matsudo & Lazaretti-Castro, 2010). Since muscle function is affected by poor nutrition, handgrip strength has also become a marker of nutritional status (Chilima & Ismail, 2001; Heimbürger, Qureshi, Blaner, Berglund & Stenvinkel, 2000; Norman, Stobäus, Gonzalez, Schulzke & Pirlich, 2011) and an outcome predictor for nutritional interventions (Norman et al., 2011). Handgrip strength is easily measured in clinical settings. Thus, given the lack of association, perhaps SARC-F and handgrip strength combined would identify the majority of those at risk more easily and quickly and be readily implemented, although further work would be needed to demonstrate this.

Past research shows that higher PASE scores, indicative of greater physical activity, are associated with sarcopenia (Basile et al., 2014; Curcio et al., 2017; Kenny, Dawson, Kleppinger, Iannuzzi-Sucich & Judge, 2003; Verlaan et al., 2017). Rizzoli et al. (2013) found that associations between self-reported and performance-based measures range from small to medium, with gait speed and chair stand among the most responsive performance-based measures. In the Melbourne sample, all three components of sarcopenia (muscle strength, mass and physical performance) were significantly associated with lower self-reported physical activity via PASE. In this study, PASE score between Melbourne sarcopenic and non-sarcopenic participants according to FNIH, EWGSOP1 and EWGSOP2 were not significantly different (all $p > 0.05$), which is inconsistent with prior literature that reported $p < 0.001$ between the groups (Curcio et al., 2017; Verlaan et al., 2017). According to EWGSOP1, this study's PASE score at baseline for sarcopenic (M: 130.76, SD: 58.76) and non-sarcopenic (M: 113.47, SD: 61.32) was higher than that reported for Italian community-dwelling older adults (sarcopenic M: 40.2, SD: 89.1; non-sarcopenic M: 92, SD: 52.4) (Curcio et al., 2017) but lower than a United Kingdom cohort (sarcopenic: M: 148, SD: 73.3; non-sarcopenic M: 193, SD: 73.6) (Verlaan et al., 2017). The mean Melbourne sample score (M: 128.8; SD: 58.97) was higher than reported for US (M: 102.9), Malaysian (M: 94.96) or Turkish community-dwelling older adults (M: 121.79, SD: 54.71) (Ayvat et al., 2017; Ismail et al., 2015; Washburn et al., 1993).

The relatively low PASE score of the Melbourne cohort may indicate that participants substitute general activity with their supervised gym time. Those who attend gyms should be encouraged to not view it as their only form of exercise, but ensure it is an addition to their regular physical activity. A recent study showed that of 103 Australians aged 50–92 years, 11% mentioned irregular activities (e.g., gardening and walking), another 11% purposeful exercise (e.g., gym and water aerobics) and 8% regular exercise (e.g., golf and tennis) (Boulton-Lewis

et al., 2019). Boulton-Lewis et al. (2019) argued that lack of awareness of exercise benefits and barriers are not new. With increasing prevalence of older adults, these issues need to be addressed and strategies promoted to increase physical activity in this population. One of the new approaches could be 'senior exercise parks' (Levinger et al., 2018; Sales, Polman, Hill & Levinger, 2017). The first outdoor exercise park trial, including a supervised 18-week exercise program using the purpose-built senior exercise park, led to improved muscle strength, balance and physical function in 62 older Melbournians, with high attendance and retention rates (Sales et al., 2017; Sales, Polman, Hill, Karaharju-Huisman & Levinger, 2015). Levinger et al. (2018) suggested that senior exercise parks could be implemented outdoors and indoors in public places in Australia. They may be free of charge, providing health, wellbeing and connection with nature, also offering group exercise classes to increase physical activity in that sector. Group exercise classes also offer social support and enhance exercise training and adherence (American College of Sports Medicine, 2014).

Regarding HRQoL, no significant difference was observed between Melbourne gyms, although non-significantly, the conventional gym scored higher in HRQoL than the HUR gym ($p = 0.116$). In the El Paso group, there were no significant differences in change for HRQoL between training groups, although HRQoL significantly improved in the ST group but not in the PT group compared to pretest. High HRQoL suggests that it was a high-functioning sample even before the intervention, and the intervention significantly contributed to an increase in HRQoL. This supports prior findings that improved function is related to and can be a predictor of HRQoL (Giles et al., 2009; Xu et al., 2018). A recent systematic analysis reported that although exercise is recommended for treatment of sarcopenia, consensus about the most effective approach remains missing (Moore et al., 2019). The El Paso results suggest that both strength and power training are suitable to improve muscle strength and function over time, but ST is more suitable to improve lean mass (ALM, BMI, ALM/BMI and ALM/h^2) and HRQoL.

In the Melbourne study, strength (chair stand) and all physical performance components (gait speed, SPPB, TUG and 400-metre walk), but not lean mass components, were significantly associated with poorer HRQoL. This supports prior literature that poorer HRQoL (using SarQoL) appears to be more related to muscle function than to muscle mass (Beaudart et al., 2018), demonstrating the importance of maintaining muscle function for healthy ageing. The Melbourne group scored significantly lower in HRQoL (M: 0.69, SD: 0.22) than the El Paso group (M: 0.82, SD: 0.16) at baseline. According to Australian population norms for HRQoL (using AQoL), most Australians (47%) had high HRQoL characterised by the highest AQoL decile (0.91–1.00) and monotonic decline with age (Hawthorne et al., 2013). HRQoL in

the Melbourne sample using AQoL-4D was lower to that reported for the US cohort using EQ-5D (sarcopenic M: 0.79, SD: 0.16; non-sarcopenic M: 0.94, SD: 0.09) (Verlaan et al., 2017). HRQoL in Melbourne and El Paso groups was not significantly different between sarcopenic and non-sarcopenic subjects (all $p > 0.05$), which is not consistent with prior literature showing that non-sarcopenic-individuals scored significantly higher in HRQoL than sarcopenic individuals ($p < 0.001$) (Beaudart et al., 2018; Verlaan et al., 2017). Again, the overall low percentage of sarcopenia (thus, higher functionality) may be a contributor to that finding.

Protein and energy intake are linked with sarcopenia (Fujita & Volpi, 2004; Millward, 2012; Robinson et al., 2017, 2018; Verlaan et al., 2017; Yanai, 2015). There is a strong correlation between muscle mass and nutritional status in this population (Landi et al., 2011). In the Melbourne study, lean mass components were significantly associated with lower self-reported protein and energy intake at baseline. The total score for the ARFS is 73 (Collins et al., 2015; the University of Newcastle, 2016), but in the current study, the average score was 35.33, indicating that participants are not achieving the right nutritional balance in their food intake. The HUR group also had significantly higher BMI, along with higher protein and energy intakes compared to the conventional group. Obesity is associated with poorer physical performance and mobility in older adults (Chang et al., 2015; De Stefano et al., 2015; Huang et al., 2019). Westerterp (2019) argued that a weight-loss program should incorporate reduced energy intake through diet rather than just exercise-induced energy expenditure. Balance between exercise and nutrition is important, as diet should not compromise any weight-loss benefit from the exercise program. It is possible that the HUR group is not obtaining as great a benefit from engaging in exercise as they could be if they were met protein intake guidelines.

It is very well established, at least in younger individuals, that ingesting high-quality protein with training augments the beneficial effects (Antonio et al., 2015; Cribb, Williams, Carey & Hayes, 2006; Cribb, Williams, Stathis, Carey & Hayes, 2007). However, older individuals require higher amounts of protein to increase protein synthesis at the same levels as a younger individual (Chernoff, 2004; Moore et al., 2014; Morton et al., 2018; Paddon-Jones et al., 2015), and the RDA is based on not becoming deficient, rather than being an optimal dose. Based on a recent meta-analysis, muscle mass increase required protein intakes of up to 1.6 g/kg/day and was more effective in resistance-trained people but less effective in people over 60 years (Morton et al., 2018). As most participants in this study had engaged in resistance training for some time, it is likely that insufficient protein was being ingested. Thus, regular protein supplementation, particularly when training, may help improve their muscle health. In the El Paso sample, following 16 weeks of training, no significant difference was observed

between obese and non-obese participants. Given the above, education on nutrition and regular physical activity, in addition to existing gym-based exercises, should be promoted at both sites.

Sarcopenia and muscle health are still unfamiliar concepts given that sarcopenia was only recognised as a muscle disease and given an ICD-10-CM-code in the US in September 2016 and in Australia in July 2019 (Anker et al., 2016; Falcon & Harris-Love, 2017; ICD10Data.com, 2018; Van Ancum et al., 2019). The Melbourne cohort is now more educated about sarcopenia, as one of the study's objectives was to raise awareness of the condition and improve muscle health. The El Paso study, as part of the Physical Fitness in the Golden Age program conducted in 2016, aimed to promote exercise among community-dwelling older adults in the El Paso region; thus, the group may not be aware of these concepts. Van Ancum et al. (2019) argued that despite ignorance, Dutch community-dwelling older adults acknowledged the importance of muscle health and readiness to treat and prevent sarcopenia, which shows potential benefits of educational initiatives to raise awareness.

Past research shows inconsistent recommendations for resting and fasting prior to DEXA and BIA testing. Exercise (resistance training, cycling) and intake of fluid/food as per normal are associated with changes in body composition via DEXA in well-trained adults (Nana, Slater, Hopkins, & Burke, 2013). Nana et al. (2013) suggest that to minimise biological and technical "noises" regarding DEXA scan, people should fast and rest before testing. However, effect of food and drink on older adults shows the opposite. Body composition on older adults was measured in fasting state and one hour after breakfast (500 ml of orange juice and one 50 g bread roll with butter) (Vilaça, Ferriolli, Lima, Paula, & Moriguti, 2009). The intake of fluid and food by older adults prior to tests do not alter the results of the parameters of body composition measured with BIA and DEXA (Vilaça et al., 2009). Vilaça et al. (2009) argue that although weight and BMI slightly but significantly change, they are clinically insignificant. A more recent study using BIA shows that the consumption of an electrolyte drink, high-fat and high-carbohydrate meals significantly increase the percentage body fat and fat mass (Androutsos, Gerasimidis, Karanikolou, Reilly, & Edwards, 2015). However, despite small significant changes in body composition, they are clinically insignificant (Androutsos et al., 2015). Both studies suggest that rigid fasting is not required for this population (Androutsos et al., 2015; Vilaça et al., 2009).

In this study, exercise, eating and drinking was allowed as per normal prior to a DEXA scan (MeasureUp, 2016b). Particularly, older adults tend to not tolerate prolonged fasting well, which may also result in deficient calorie intake on the testing day (Vilaça et al., 2009). Participants in this study were scheduled for BIA and DEXA from 8.30am until 4.30pm. If

fasting was required, it might negatively affect their health, body composition, physical performance and general wellbeing on that day. Since catering was provided, subjects could have some fruit and drink (water/juice) if needed before testing, however they were advised to come back for a larger meal after measurements. The chance of technical errors was reduced by rigorous standardisation of subject positioning on the electrodes of the BIA scale (Vilaça et al., 2009). BIA scale was positioned on hard flooring. Participants stood on the BIA scale in bare feet with arms away from the body as advised by Tanita sales representative. DEXA operators performed a rigorous protocol of removing metal from clothing (zippers, buckles) and subject positioning (MeasureUp, 2016b). For maximum reliability, follow-up DEXA scans should be performed on the same time of day, with similar food and fluid intake and training regime (MeasureUp, 2016b).

Past research shows that significant differences were observed in whole-body DEXA results between Hologic and GE Lunar systems (Shepherd et al., 2012; Siglinsky, Binkley & Krueger, 2018). While both machines Lunar DPX and Hologic QDR show similar results for lean and fat mass, bone mineral content is 17% higher for the Lunar DPX (Horber, Thomi, Casez, Fonteille, & Jaeger, 1992). When using Hologic QDR, drinking water (median 0.83 l) does not alter fat and bone mass, however it significantly increases lean mass at lunch and dinner. Light breakfast with fluid intake (below 500 m) has no significant effect on body composition. Weight increases were observed at lunch and dinner and decreases in the time between them DPX (Horber et al., 1992). Consequently, Horber et al. (1992) advise to use the same DEXA machine and consider hydration and food intake at follow-up scans. Based on this evidence, two different DEXA machines used for the Melbourne and El Paso cohorts (Lunar and Hologic, respectively), as well as exercise and food/drink intake prior to testing, could significantly affect the whole-body DEXA results of these two studies.

The strength of this projects is comparison of two studies that include community-dwelling older adults of various ethnic groups. Both studies underwent DEXA for body composition and the same instrument on HRQoL (AQoL-4D). Another strength is that sarcopenia was assessed using three major operational definitions (FNIH, EWGSOP and EWGSOP2). The Melbourne study followed the 4-step pathways (F-A-C-S) according to EWGSOP2 and explored chair stand in addition to handgrip strength and TUG and 400mW in addition to gait speed and SPPB.

Chapter 7: Conclusions

7.1 Overview

Sarcopenia prevalence in older adults participating in supervised exercise programs was low and varied according to definition applied. A universally accepted definition of sarcopenia is recommended to enable consistent diagnosis and implementation in clinical settings. El Paso study participants were fit to begin with, hence they had high HRQoL. Due to low prevalence of sarcopenia at baseline in the El Paso cohort, it has not significantly changed by exercise, however significant changes were observed in sarcopenia components. Strength training significantly contributed to muscle strength, lean mass, function and HRQoL, but power/agility training only to muscle strength and function in older adults. In can be concluded that exercises, particularly ST, can improve sarcopenia components and HRQoL in community-dwelling older adults. Sarcopenia components have inconsistent associations with poorer HRQoL in community-dwelling older adults, perhaps indicating that the effects of sarcopenia on HRQoL are most pronounced in older age. Ensuring maintenance of adequate nutrition and non-supervised physical activity may enhance the benefits of supervised training for older adults.

7.2 Limitations and future direction

Both studies have several limitations. The two studies were carried out in Australia and the US, which are Western first-world countries that have better access to resources, food and diet than third world countries, thus results may not be meaningful for the overall global population. Another limitation is unequal sample sizes in both studies. Due to the cross-sectional design and convenience of the Melbourne sample, the population is unrepresentative and has potentially unbalanced groups at HUR and conventional gyms. The 400mW course is normally a 20-metre course repeated 20 times. However, due to limited gym space, participants walked a 10-metre course 40 times. In the El Paso group, gait speed was assessed from a six-minute walk performed at normal speed on a treadmill, but ideally, it should be done on a normal walking surface. The surveys are subject to recall bias and some participants may have had difficulty understanding questions. Cruz-Jentoft et al. (2018) recently acknowledged a reporting error regarding their published ALM/h^2 cut-off point for women, which is < 5.5 kg/m^2 not < 6.0 kg/m^2 according to EWGSOP2. Since the authors' corrigendum came to my attention after completing all analyses for this thesis, sarcopenia according to the original EWGSOP2 article will be reanalysed for publication purposes. In any case, that oversight does not alter the major conclusions from the thesis, as no cases were identified in El Paso with

EWGSOP1 (and the EWGSOP2 value is lower) and the change has no bearing on EWGSOP1. Thus, the only effect may be a slightly lower prevalence in Melbourne females with EWGSOP2, and values were already relatively low. There are significant differences in whole-body DEXA results between Hologic and GE Lunar systems (Shepherd et al., 2012; Siglinsky, Binkley & Krueger, 2018). However, since there is no gold standard for DEXA scanners in relation to sarcopenia, this limitation is unavoidable. Consequently, standards of accuracy for DEXA systems should be implemented to ensure consistency in measurements. For accuracy reasons, any post-testing using DEXA should be performed on the same machine. Although participants were asked to remove metallic items, textiles can affect DEXA-derived body composition and BMD results (Siglinsky et al., 2018). Even small amounts of reflective material could amend mass measurements by approximately 25% of the least significant change. Thus, clothes made of dense textiles, such as wool and denim, or made with reflective material and metallic thread, should be avoided during DEXA scans (Siglinsky et al., 2018).

Practitioners could use strategies incorporating nutritional supplements and exercises, particularly protein supplementation and resistance training, to prevent loss of muscle mass and muscle strength. Providers of gyms for seniors could incorporate assessment of HRQoL into their professional practice to improve the health and wellbeing of clients. The research abstract regarding the Melbourne study has been recently accepted for a conference to be held in Sydney on 22–23 November 2019. Some El Paso findings have been already presented at conferences in the US and New Zealand (see Appendix S). The Melbourne study also incorporated 6- and 12-month post-tests, which will enable investigation of effects of training over time. Further, an ongoing study is recommended to better understand the onset and outcomes of sarcopenia using resistance training. Both Melbourne and El Paso studies could target nutrition to optimise participants' nutritional intake. Future design could include a control group. It could also control physical activity, monitor external physical activities and regulate/monitor nutrition. In addition, future research should explore if educational activities improve knowledge about sarcopenia and promote awareness of muscle health, and if this contributes to prevention of sarcopenia and decreases the burden on the healthcare system. Due to the lack of agreement with respect to the diagnostic variables and how these are operationalised, future studies should focus on assessing sarcopenia components (muscle strength, lean mass and physical performance), HRQoL and nutrition to improve health outcomes in older adults. Importantly, work should focus on analysing which variables have the most clinical relevance to promote their use in any universally adopted definition.

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Appendices

Appendix A. SARC-F

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

About you

Date of birth: _____/_____/_____ **Gender:** Male ☐ Female ☐
DD MM YYYY

SARC-F Screen for Sarcopenia

SARC-F is a rapid diagnostic test for sarcopenia (a loss of muscle mass and strength). It has five components: strength, assistance with walking, rise from a chair, climb stairs, and falls. (Note: 10 pounds equals 4.5 kg). The following five questions will only take 1–2 minutes to complete. Thank you.

Please tick where appropriate.

1. How much difficulty do you have in lifting and carrying 10 pounds?
   None ☐ Some ☐ A lot or unable ☐
2. How much difficulty do you have walking across the room?
   None ☐ Some ☐ A lot, use aids, or unable ☐
3. How much difficulty do you have transferring from a chair or bed?
   None ☐ Some ☐ A lot or unable without help ☐
4. How much difficulty do you have climbing a flight of 10 stairs?
   None ☐ Some ☐ A lot or unable ☐
5. How many times have you fallen in the past year?
   None ☐ 1–3 falls ☐ 4 or more falls ☐

Thank you for your time completing this survey!

Note. Reprinted from "SARC-F: a symptom score to predict persons with sarcopenia at risk for poor functional outcomes," by T. K. Malmstrom, D. K. Miller, E. M.Simonsick, L. Ferrucci, & J. E. Morley, 2016, *Journal of cachexia, sarcopenia and muscle, 7*(1), 531. https://doi.org/10.1002/jcsm.12048. Reprinted with permission.

Appendix B. PASE

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

About you

Date of birth: _____/_____/_____ **Gender:** Male ☐ Female ☐
DD MM YYYY

Physical Activity Scale for the Elderly (PASE)

PASE assesses physical activity among older adults. It has three sections: leisure time activity, household activity, and work-related activity (Note: Question 10b: 50 pounds equals 23 kg). The following 10 questions will take about 10 min to complete. Thank you.

Please tick or write an answer where appropriate.

Leisure time activity

1. Over the past 7 days, how often did you participate in sitting activities, such as reading, watching TV or doing handcrafts?

[0.] NEVER *(go to Question 2)*

[1.] SELDOM (1–2 DAYS)

[2.] SOMETIMES (3–4 DAYS)

[3.] OFTEN (5–7 DAYS)

1.a **What were these activities?**

_____

1.b **On average, how many hours did you engage in these sitting activities?**

[1.] Less than 1 hour

[2.] 1 but less than 2 hours

[3.] 2–4 hours

[4.] more than 4 hours

2. Over the past 7 days, how often did you take a walk outside your home or yard for any reason? For example, for fun or exercise, walking to work, walking the dog, etc.

[0.] NEVER *(go to Question 3)*

[1.] SELDOM (1–2 DAYS)

[2.] SOMETIMES (3–4 DAYS)

[3.] OFTEN (5–7 DAYS)

2a. **On average, how many hours per day did you spend walking?**

[1.] Less than 1 hour

[2.] 1 but less than 2 hours

[3.] 2–4 hours

[4.] more than 4 hours

3. Over the past 7 days, how often did you engage in light sport or recreational activities, such as bowling, golf with a cart, shuffleboard, fishing from a boat or pier or other similar activities?

[0.] NEVER *(go to Question 4)*

[1.] SELDOM (1–2 DAYS)

[2.] SOMETIMES (3–4 DAYS)

[3.] OFTEN (5–7 DAYS)

3.a **What were these activities?**

_____

3.b **On average, how many hours did you engage in these light sport or recreational activities?**

[1.] Less than 1 hour

[2.] 1 but less than 2 hours

[3.] 2–4 hours

[4.] more than 4 hours

4. Over the past 7 days, how often did you engage in moderate sport and recreational activities, such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball or other similar activities?

[0.] NEVER *(go to Question 5)*

[1.] SELDOM (1–2 DAYS)

[2.] SOMETIMES (3–4 DAYS)

[3.] OFTEN (5–7 DAYS)

4.a **What were these activities?**

_____

4.b **On average, how many hours did you engage in these moderate sport or recreational activities?**

[1.] Less than 1 hour

[2.] 1 but less than 2 hours

[3.] 2–4 hours

[4.] more than 4 hours

5. Over the past 7 days, how often did you engage in strenuous sport and recreational activities, such as jogging, swimming, cycling, singles tennis, aerobic dance, skiing (downhill or cross-country) or other similar activities?

[0.] NEVER *(go to Question 6)*

[1.] SELDOM (1–2 DAYS)

[2.] SOMETIMES (3–4 DAYS)

[3.] OFTEN (5–7 DAYS)

5.a **What were these activities?**

_____

5.b **On average, how many hours did you engage in these strenuous sport or recreational activities?**

[1.] Less than 1 hour

[2.] 1 but less than 2 hours

[3.] 2–4 hours

[4.] more than 4 hours

6. Over the past 7 days, how often did you do any exercises specifically to increase muscle strength and endurance such as lifting weights or push-ups, etc?

[0.] NEVER *(go to Question 7)*

[1.] SELDOM (1–2 DAYS)

[2.] SOMETIMES (3–4 DAYS)

[3.] OFTEN (5–7 DAYS)

6.a **What were these activities?**

_____

6.b **On average, how many hours did you engage in these strenuous sport or recreational activities?**

[1.] Less than 1 hour

[2.] 1 but less than 2 hours

[3.] 2–4 hours

[4.] more than 4 hours

Household activity

7. **During the past 7 days, have you done any light housework, such as dusting or washing dishes?**

[1.] NO [2.] YES

8. **During the past 7 days, have you done any heavy housework or chores, such as vacuuming, scrubbing floors, washing windows, or carrying wood?**

[1.] NO [2.] YES

9. **During the past 7 days, did you engage in any of the following activities? Please answer YES or NO for each item.**

	NO	YES
a. Home repairs like painting, wallpapering, electrical work, etc.	1	2
b. Lawn work or yard care, including snow or leaf removal, wood chopping, etc.	1	2
c. Outdoor gardening	1	2
d. Caring for another person, such as children, dependent spouse, or another adult	1	2

Work-related activity

10. During the past 7 days, did you work for pay or as a volunteer?

[1.] NO *(End of survey)* [2.] YES

10a. **How many hours per week did you work for pay and or as a volunteer?**

____ hours

10b. **Which of the following categories best describes the amount of physical activity required on your job and or volunteer work?**

[1.] Mainly sitting with some slight arm movement **[Examples:** office worker, watchmaker, seated assembly line worker, bus driver, etc.]

[2.] Sitting or standing with some walking [**Examples:** cashier, general office worker, light tool and machinery worker]

[3.] Walking with some handling of materials generally weighing less than 50 pounds **[Examples:** mailman, waiter/waitress, construction worker, heavy tool and machinery worker]

[4.] Walking and heavy manual work often requiring handling of materials weighting over 50 pounds **[Examples:** lumberjack, stone mason, farm or general labourer]

Thank you for your time completing this survey!

Note. Reprinted from "The Physical Activity Scale for the Elderly (PASE): development and evaluation," by R. A. Washburn, K. W. Smith, A. M. Jette, C. A. & Janney, 1993, *Journal of clinical epidemiology*, 46(2), 153–162. https://doi.org/10.1016/0895-4356(93)90053-4. Reprinted with permission.

Appendix C. AQoL-4D

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

About you

Date of birth: _____/_____/_____ **Gender:** Male ☐ Female ☐
DD MM YYYY

Assessment of Quality of Life (AQoL-4D)

This Assessment of Quality of Life measures health-related quality of life. AQoL-4D has four dimensions: independent living, mental health, relationships, and senses. The following 12 questions will take about two minutes to complete. Thank you.

Tick the box that best describes your situation as it has been over the past week.

Q1 Do you need any help looking after yourself? (For example: dressing, bathing, eating)

- ❑ I need no help at all.
- ❑ Occasionally I need some help with personal care tasks.
- ❑ I need help with the more difficult personal care tasks.
- ❑ I need daily help with most or all personal care tasks.

Q2 When doing household tasks: (For example: cooking, cleaning the house, washing)

- ❑ I need no help at all.
- ❑ Occasionally I need some help with household tasks.
- ❑ I need help with the more difficult household tasks.
- ❑ I need daily help with most or all household tasks.

Q3 Thinking about how easily you can get around your home and community:

- ❑ I get around my home and community by myself without any difficulty.
- ❑ I find it difficult to get around my home and community by myself.
- ❑ I cannot get around the community by myself, but I can get around my home with some difficulty.
- ❑ I cannot get around either the community or my home by myself.

Q4 Because of your health, your relationships (for example: with your friends, partner or parents) generally:

- ❑ Are very close and warm.
- ❑ Are sometimes close and warm.
- ❑ Are seldom close and warm.
- ❑ I have no close and warm relationships.

Tick the box that best describes your situation as it has been over the past week.

Q5 Thinking about your relationship with other people:

- ❑ I have plenty of friends, and am never lonely.
- ❑ Although I have friends, I am occasionally lonely.
- ❑ I have some friends, but am often lonely for company.
- ❑ I am socially isolated and feel lonely.

Q6 Thinking about your health and your relationship with your family:

- ❑ My role in the family is unaffected by my health.
- ❑ There are some parts of my family role I cannot carry out.
- ❑ There are many parts of my family role I cannot carry out.
- ❑ I cannot carry out any part of my family role.

Q7 Thinking about your vision, including when using your glasses or contact lenses if needed:

- ❑ I see normally
- ❑ I have some difficulty focusing on things, or I do not see them sharply.
  For example: small print, a newspaper or seeing objects in the distance
- ❑ I have a lot of difficulty seeing things.
  My vision is blurred. For example: I can see just enough to get by with.
- ❑ I only see general shapes, or am blind
  For example: I need a guide to move around.

Q8 Thinking about your hearing, including using your hearing aid if needed:

- ❑ I hear normally.
- ❑ I have some difficulty hearing or I do not hear clearly.
  For example: I ask people to speak up, or turn up the TV or radio volume.
- ❑ I have difficulty hearing things clearly
  For example: Often I do not understand what is said. I usually do not take part in conversations because I cannot hear what is said.
- ❑ I hear very little indeed
  For example: I cannot fully understand loud voices speaking directly to me.

Q9 When you communicate with others: (For example: by talking, listening, writing or signing)

- ❑ I have no trouble speaking to them or understanding what they are saying.
- ❑ I have some difficulty being understood by people who do not know me. I have no trouble understanding what others are saying to me.
- ❑ I am only understood only by people who know me well. I have great trouble understanding what others are saying to me.
- ❑ I cannot adequately communicate with others.

Tick the box that best describes your situation as it has been over the past week.

Q10 Thinking about how you sleep:

- ❑ I am able to sleep without difficulty most of the time.
- ❑ My sleep is interrupted some of the time, but I am usually able to go back to sleep without difficulty.
- ❑ My sleep is interrupted most nights, but I am usually able t go back to sleep without difficulty.
- ❑ I sleep in short bursts only. I am awake most of the nights.

Q11 Thinking about how you generally feel:

- ❑ I do not feel anxious, worried or depressed.
- ❑ I am slightly anxious, worried or depressed.
- ❑ I feel moderately anxious, worried or depressed.
- ❑ I am extremely anxious, worried or depressed.

Q12 How much pain or discomfort do you experience?

- ❑ None at all.
- ❑ I have moderate pain.
- ❑ I suffer from severe pain.
- ❑ I suffer unbearable pain.

Thank you for your time completing this survey!

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Appendix D. AES

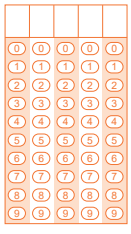
Please write your name in pencil only:

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

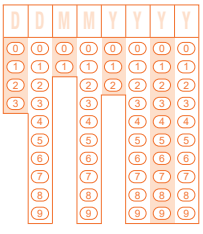
Australian Eating Survey Online

Please leave this space for the researchers to complete:

ID



Date of Birth



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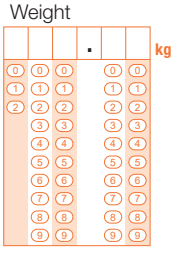

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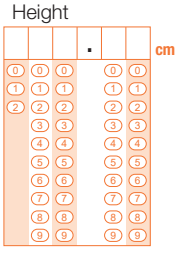

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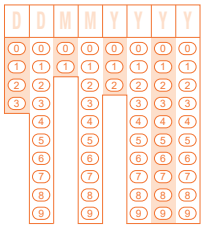

PLEASE READ THESE INSTRUCTIONS BEFORE YOU START

This is a survey about the food you eat. Read it carefully and fill in the ovals to show what you usually eat.

REMEMBER: ***There are no right or wrong answers.***

How to fill in this survey

- Use a blue/black ballpoint pen or 2B pencil
- Do not use a red or felt tip pen
- If you make a mistake, either erase or place a cross through the incorrect oval and fill in the correct oval
- Fill in only one oval for each question
- Do not make any extra marks on this form

Please MARK LIKE THIS: ○ ● ○ ○

NOT LIKE THIS: ✓ x —

Please CORRECT LIKE THIS: ○ ■ ○ ●

1 How old are you?

2 When is your birthday?

Month

- ○ January
- ○ February
- ○ March
- ○ April
- ○ May
- ○ June
- ○ July
- ○ August
- ○ September
- ○ October
- ○ November
- ○ December
- ○ Not sure

Day

- ○ 1 ○ 17
- ○ 2 ○ 18
- ○ 3 ○ 19
- ○ 4 ○ 20
- ○ 5 ○ 21
- ○ 6 ○ 22
- ○ 7 ○ 23
- ○ 8 ○ 24
- ○ 9 ○ 25
- ○ 10 ○ 26
- ○ 11 ○ 27
- ○ 12 ○ 28
- ○ 13 ○ 29
- ○ 14 ○ 30
- ○ 15 ○ 31
- ○ 16 ○ Not sure

Year

○ Not sure

3 Are you?

- ○ Male
- ○ Female

4 Do you take vitamins?

○ No ○ Yes

Please go to page 3.

a How many vitamin tablets do you take each week?

- ○ 2 or less
- ○ 3-5
- ○ 6-9
- ○ 10 or more

b How many years have you been taking them?

- ○ 0-1 years
- ○ 2-4
- ○ 5-9
- ○ 10 years or more

Think about what you ate over the last 3-6 months when you answer these questions

GENERAL QUESTIONS

A **How many days per week do you usually have something to eat for breakfast?**

- ○ Never
- ○ 1-2 days
- ○ 3-4 days
- ○ 5 or more days
- ○ Not sure

B **Where do you usually eat breakfast?**

- ○ At home
- ○ On the way to school/work/TAFE/college/university
- ○ At school/work/TAFE/college/university
- ○ Don't eat breakfast
- ○ Other

C **How many pieces of fruit do you eat?**
(include all types)

- ○ None
- ○ Less than 1 per week
- ○ 1-2 per week
- ○ 3-4 per week
- ○ 5-6 per week
- ○ Once per day
- ○ 2-3 per day
- ○ 4 or more per day

D **How many times a week do you eat vegetables with your meal at night?**
(not including hot chips)

- ○ Never
- ○ Less than once per week
- ○ 1-2 per week
- ○ 3-4 per week
- ○ 5 or more per week

E **How often do you eat takeaway foods? eg. chinese, fish and chips, hamburger and chips/fries, pizza**

- ○ Never
- ○ Less than once per week
- ○ 1-2 per week
- ○ 3-4 per week
- ○ 5-6 per week
- ○ Once a day
- ○ 1 or more per day

F **How many times a week do you eat your meal at night in front of the television (TV)?**

- ○ Never
- ○ Less than once per week
- ○ 1-2 per week
- ○ 3-4 per week
- ○ 5-6 per week
- ○ Every day

G **How much time each day do you spend watching television?**

- ○ 0-1 hour per day
- ○ 2-3 hours per day
- ○ 4-5 hours per day
- ○ 6 or more hours per day

H **How much time each day do you spend on the computer or playing video games?**

- ○ 0-1 hour per day
- ○ 2-3 hours per day
- ○ 4-5 hours per day
- ○ 6 or more hours per day

Think about what you ate over the last 3-6 months when you answer these questions

GENERAL QUESTIONS (continued)

I **How much money do you usually spend each week on buying lunches, snacks and drinks (eg. coffee)?**

- ○ Less than $5 per week
- ○ $5-$15 per week
- ○ $15-$25 per week
- ○ $25-$35 per week
- ○ $35-$49 per week
- ○ $50 or more per week

J **How many times a day do you eat snacks?**

- ○ Less than once per day
- ○ 1-2 per day
- ○ 3-4 per day
- ○ 5-6 per day
- ○ 7 or more per day

EXAMPLE QUESTION

Add up how many times a day you have a glass of milk, a tub of yoghurt or a slice of cheese

If you eat:

- *2 slices of cheese on sandwich per day*
- *1 glass milk with Milo per day*
- *1 tub yoghurt per day*

4 times total for the day ... you would answer like this →

- ○ Never
- ○ Less than 1 per month
- ○ 1 per week or less
- ○ 2-6 per week
- ○ 1 per day
- ○ 2-3 per day
- ■ 4-6 per day
- ○ 7 or more per day

K **Add up how many times a day you have a glass of milk, a tub of yoghurt or a slice of cheese**

- ○ Never
- ○ Less than 1 per month
- ○ 1 per week or less
- ○ 2-6 per week
- ○ 1 per day
- ○ 2-3 per day
- ○ 4-6 per day
- ○ 7 or more per day

L **Add up how many glasses of softdrink or cordial you have each day?** *(all types)*

- ○ Less than 1 per day
- ○ 1 per day
- ○ 2-3 per day
- ○ 4-6 per day
- ○ 7 or more per day

EXAMPLE QUESTION

How often do you eat the following foods:

If you drink:

One can of diet softdrink 2-3 times per week

Then your answer should look like this →

Diet softdrink *(1 can or glass)*

- ○ Never
- ○ 1-3 per month
- ○ 1 per week
- ■ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

Think about what you ate over the last 3-6 months when you answer these questions

DRINKS

Fill in one oval for each food item

D1 **DIET softdrink**
eg. Diet coke
(1 can or glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

D2 **Softdrink (NOT DIET) including flavoured mineral water**
eg. lemonade, coke, fanta, flavoured mineral water
(1 can or glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

D3 **Water – including bottled water, unflavoured mineral water, tap water**
(1 glass)

- ○ Never
- ○ Less than 1 per day
- ○ 1-3 glasses per day
- ○ 4-6 glasses per day
- ○ 7 or more glasses per day

D4 **Fruit juice-based drinks**
eg. orange juice or Popper
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

D5 **Cordial or 'make up'**
eg. Cottee's crush, raspberry
(1 glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

D6 **Tea or Coffee**
(1 cup or mug)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

D7 **Beer**
(1 can, bottle or glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

D8 **Wine or wine coolers**
eg. West Coast cooler
(1 can, bottle or glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

D9 **Spirits eg. vodka, bourbon**
(1 drink or shot)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

EXAMPLE QUESTION

If you eat:

- *1 glass plain milk with cereal per day*
- *2 glasses milk with Milo per day*

3 glasses total for the day ... you would answer like this →

Milk – glass or with cereal
(1 glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1 glass per week or less
- ○ 2-6 glasses per week
- ○ 1 glass per day
- ■ 2-3 glasses per day
- ○ 4 or more glasses per day

Think about what you ate over the last 3-6 months when you answer these questions

MILK AND DAIRY FOODS

Fill in one oval for each food item

DF1 What TYPE of milk do you usually drink?

- ○ Soy milk
- ○ Rice milk
- ○ Normal milk
- ○ Reduced fat milk
- ○ Skim milk
- ○ Not sure
- ○ Don't drink milk

DF2 Flavoured milk
eg. Moove, Oak, hot chocolate, milkshake, thickshake, smoothie
(1 glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2-3 per day
- ○ 4 or more per day

DF3 Plain milk – glass or with cereal
(1 glass)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2-3 per day
- ○ 4 or more per day

DF4 Cream or sour cream

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-4 per week
- ○ 5 or more per week

DF5 Ice cream – vanilla, chocolate, strawberry, sundaes, cones

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

DF6 Frozen yoghurt
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

DF7 Yoghurt (not frozen) plain or flavoured eg. Ski, Yoplait, Vaalia
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2 or more per day

DF8 Cottage cheese or ricotta
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2 or more per week

DF9 Cheese – including cheese on sandwiches, biscuits or on toast
(1 slice)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2-3 per day
- ○ 4 or more per day

DF10 Cheese spread, cream cheese *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ 1 per week
- ○ 2-6 per week
- ○ 1 per day
- ○ 2-3 per day
- ○ 4 or more per day

Think about what you ate over the last 3-6 months when you answer these questions

BREADS AND CEREALS

Fill in one oval for each food item

B1 **Muesli**
(1 bowl)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5-7 per week
- 2 or more per day

B2 **Cooked porridge**
(1 bowl)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5-7 per week
- 2 or more per day

B3 **Breakfast cereal**
eg. Weet-bix, Nutri-grain, Cornflakes Sultana Bran
(1 bowl)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 times per week
- 5-7 times per week
- 2 or more times per day

B4 **What type of bread do you usually eat?**
- Brown (multigrain, wholemeal)
- White
- Other
- Not sure

B5 **Bread, pita bread, roll or toast**
all types
(1 slice)
- Never
- Less than 1 per month
- 1 per week or less
- 2-4 per week
- 5-7 per week
- 2-3 per day
- 4 or more per day

B6 **English muffin, bagel or crumpet**
(1)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

B7 **Rice**
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

B8 **Other grains**
eg. cous cous, burghul
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

B9 **Noodles**
eg. egg noodles (yellow), rice noodles (white)
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

B10 **Pasta**
eg. spaghetti, lasagne, pasta bake
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

Think about what you ate over the last 3-6 months when you answer these questions

SWEETS AND SNACKS

Fill in one oval for each food item

S1 **Cakes, sweet muffins, scones, pikelets, pancakes, hot cakes eg. apple muffin, chocolate cake, lamington** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S2 **Sweet pies or sweet pastries eg. apple pie, danish** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S3 **Other puddings or desserts (not ice cream) eg. chocolate mousse, sticky date pudding** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S4 **Plain sweet biscuits eg. Arrowroot, Morning Coffee, Tiny Teddies** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S5 **Cream or chocolate biscuits eg. Tim Tams, shortbread cream** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S6 **Dry or savoury biscuits, crispbread, crackers eg. Saos, Vita Weats, Jatz, Shapes, rice crackers, Cruskits** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S7 **Savoury combination snacks – biscuits and cheese eg. Le Snak, Snack abouts** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S8 **Sweet combination snacks eg. Dunkaroos** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S9 **Snack noodles eg. 2-minute noodles, Monster noodles** *(1 serving)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

S10 **Fruit bars eg. Roll Ups** *(1 bar)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5-6 per week
- ○ 1 per day
- ○ 2 or more per day

S11 **Snack bars eg. K-time twist bar** *(1 bar)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5-6 per week
- ○ 1 per day
- ○ 2 or more per day

S12 **Muesli bars eg. Yoghurt Tops** *(1 bar)*

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5-6 per week
- ○ 1 per day
- ○ 2 or more per day

Think about what you ate over the last 3-6 months when you answer these questions

MAIN MEALS

Fill in one oval for each food item

M1 **Mince dish eg. spaghetti bolognese, rissoles, shepherd's pie, lasagne**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M2 **Beef or lamb pieces and sauce WITHOUT vegetables eg. beef stroganoff**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M3 **Beef or lamb pieces and sauce WITH vegetables eg. stir fry**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M4 **Plain meat (beef or lamb) (eg. roast, chops, steak) WITHOUT vegetables or salad**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M5 **Plain meat (beef or lamb) (eg. roast, chops, steak) WITH vegetables or salad**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M6 **Chicken pieces and sauce WITHOUT vegetables eg. satay chicken**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M7 **Chicken pieces and sauce WITH vegetables eg. stir fry**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M8 **Chicken crumbed eg. chicken nuggets, KFC pieces, schnitzel**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 times per week
- 5 or more times per week

M9 **Plain chicken (eg. roast or BBQ) WITHOUT vegetables**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M10 **Plain chicken (eg. roast or BBQ) WITH vegetables**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M11 **Pork pieces and sauce WITHOUT vegetables eg. sweet and sour pork**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M12 **Pork pieces and sauce WITH vegetables eg. stir fry**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

Think about what you ate over the last 3-6 months when you answer these questions

MAIN MEALS (continued)

Fill in one oval for each food item

M13 Plain pork (eg. roast or chops) WITHOUT vegetables
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M14 Plain pork (eg. roast or chops) WITH vegetables
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M15 Liver – beef, calf, chicken (including paté)
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M16 Fish crumbed or battered eg. fish & chips, fish fingers
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M17 Fresh fish not crumbed or battered
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M18 Canned tuna, salmon, sardines including patties
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M19 Other seafood eg. prawns, lobster
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M20 Creamy soup
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M21 Clear soup with rice or noodles
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M22 Tacos, burritos, enchiladas
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M23 Sausages, frankfurts, Pluto Pup
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

M24 Hamburger – all types
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

Think about what you ate over the last 3-6 months when you answer these questions

MAIN MEALS (continued)

Fill in one oval for each food item

M25 Pizza
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M26 Pie, sausage roll, chiko roll
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M27 Hot dog
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M28 Savoury pastries
eg, spinach and cheese triangles
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

M29 Hash browns, potato scallops
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

OTHER FOODS

Fill in one oval for each food item

O1 Chips (not potato) eg. Twisties, corn chips, burger rings
(1 packet)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5-6 per week
- 1 per day
- 2 or more per day

O2 Potato chips or crisps
eg. plain, salt and vinegar
(1 packet)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5-6 per week
- 1 per day
- 2 or more per day

O3 Ice block - creamy
eg. Paddle Pop, Magnum, Cornetto
(1 ice block)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5-6 per week
- 1 per day
- 2 or more per day

O4 Ice block – water
eg. Frosty Fruit, lemonade
(1 ice block)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

O5 Chocolate
eg. plain chocolate, Mars Bar, Snickers, Milky Way
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 times per week
- 5-6 times per week
- Once per day
- 2 or more times per day

O6 Lollies without chocolate
eg. lollipops, snakes, Skittles, Starburst
(1 serving)
- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 times per week
- 5-6 times per week
- Once per day
- 2 or more times per day

Think about what you ate over the last 3-6 months when you answer these questions

OTHER FOODS (continued)

Fill in one oval for each food item

O7 Low fat salad dressing or mayonnaise
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

O8 Salad dressing or mayonnaise – not low fat
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

O9 Nuts eg. peanuts, almonds
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

O10 Jam, honey, golden syrup, marmalade
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 times per week
- ○ 5-6 times per week
- ○ Once per day
- ○ 2 or more times per day

O11 Peanut butter, Nutella
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 times per week
- ○ 5-6 times per week
- ○ Once per day
- ○ 2 or more times per day

O12 Vegemite, Mighty Mite, Promite, Marmite
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 times per week
- ○ 5-6 times per week
- ○ Once per day
- ○ 2 or more times per day

O13 Tomato sauce, barbecue sauce
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

O14 Devon, salami
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

O15 Bacon, ham
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

O16 Eggs eg. boiled, scrambled
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

O17 Jelly
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

You have nearly finished.

Only "FRUIT AND VEGETABLES" to go!

Think about what you ate over the last 3-6 months when you answer these questions

FRUIT AND VEGETABLES

Fill in one oval for each food item

F1 Hot chips bought from a shop eg. McDonald's fries
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F2 Hot chips cooked at home eg. oven fries, wedges
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F3 Potato boiled, mashed, baked
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F4 Pumpkin
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F5 Sweet potato
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F6 Cauliflower
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F7 Green beans
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F8 Spinach
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F9 Cabbage or brussel sprouts
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F10 Peas
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 times per month
- ○ Once per week
- ○ 2-4 times per week
- ○ 5-6 times per week
- ○ Once per day
- ○ 2 or more times per day

F11 Broccoli
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 times per month
- ○ Once per week
- ○ 2-4 times per week
- ○ 5-6 times per week
- ○ Once per day
- ○ 2 or more times per day

F12 Carrots
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 times per month
- ○ Once per week
- ○ 2-4 times per week
- ○ 5-6 times per week
- ○ Once per day
- ○ 2 or more times per day

Think about what you ate over the last 3-6 months when you answer these questions

FRUIT AND VEGETABLES (continued)

Fill in one oval for each food item

F13 Zucchini, eggplant, squash
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F14 Capsicum
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F15 Corn, sweetcorn, corn on the cob
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F16 Mushrooms
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F17 Tomatoes
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F18 Lettuce
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 times per month
- ○ Once per week
- ○ 2-4 times per week
- ○ 5-6 times per week
- ○ Once per day
- ○ 2 or more times per day

F19 Celery, cucumber
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F20 Avocado
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F21 Onion, spring onion, leek
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F22 Soybeans, tofu
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F23 Baked beans
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

F24 Other beans, lentils eg. chickpeas, split peas
(1 serving)

- ○ Never
- ○ Less than 1 per month
- ○ 1-3 per month
- ○ Once per week
- ○ 2-4 per week
- ○ 5 or more per week

Think about what you ate over the last 3-6 months when you answer these questions

FRUIT AND VEGETABLES (continued)

Fill in one oval for each food item

F25 **Canned fruit**
eg. peaches, Two fruits
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

F26 **Fruit salad**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

F27 **Dried fruit**
eg. sultanas, dried apricots
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

F28 **Apple or pear**
(1 serving)

- Never
- Less than 1 per month
- 1-3 times per month
- Once per week
- 2-4 times per week
- 5-6 times per week
- Once per day
- 2 or more times per day

F29 **Orange, mandarin, grapefruit**
(1 serving)

- Never
- Less than 1 per month
- 1-3 times per month
- Once per week
- 2-4 times per week
- 5-6 times per week
- Once per day
- 2 or more times per day

F30 **Banana**
(1 serving)

- Never
- Less than 1 per month
- 1-3 times per month
- Once per week
- 2-4 times per week
- 5-6 times per week
- Once per day
- 2 or more times per day

WHEN THE FOLLOWING FRUIT IS IN SEASON, HOW OFTEN DO YOU USUALLY EAT IT?

Fill in one oval for each food item

FS1 **Peach, nectarine, plum or apricot**
(1)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

FS2 **Mango or paw-paw**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

FS3 **Pineapple**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

FS4 **Grapes, strawberries, blueberries**
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

FS5 **Melon**
eg. watermelon, rockmelon, honeydew melon
(1 serving)

- Never
- Less than 1 per month
- 1-3 per month
- Once per week
- 2-4 per week
- 5 or more per week

Think about what you ate over the last 3-6 months when you answer these questions

Please list any foods that you regularly eat that you have not been asked about:

You have finished.
Thank you!

Appendix E. Recruitment Poster

Victoria University is seeking participants for a research project with Uniting AgeWell, aimed at investigating sarcopenia risk among exercise training clients.

Who can participate?
Anyone already doing strength training with Uniting AgeWell, or planning to start, can take part in the study.

What is involved?
Complete a series of surveys, fitness assessments and free body composition tests.

Why get involved?
Enjoy the benefits of better health and movement to help you age well and contribute to enhanced treatment options for people with sarcopenia.

Sarcopenia is a loss of muscle mass and strength with age, affects older adults and can lead to disability, falls, fractures and loss of independence.

To find out more about the project and participation requirements, ask Uniting AgeWell therapists or admin staff or contact the Victoria University researchers: Chief Investigator Professor Alan Hayes on 0401 692 118 or Student Researcher Ewelina Akehurst on 0406 786 051.

VICTORIA UNIVERSITY
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Uniting AgeWell

Appendix F. Consent Form

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

Title	Evaluation of sarcopenia risk factors through exercise training
Short Title	***Your Muscles Matter***
Project Number	25901
Project Sponsor	Victoria University
Chief Investigator	Prof. Alan Hayes (Victoria University)
Student Researcher	Ewelina Akehurst (Victoria University)
Associate Investigators	Dr David Scott (Monash University) Prof. Sandor Dorgo (The University of Texas at El Paso, USA)
Location	Uniting AgeWell Allied Health and Therapy Centres at Forest Hill, Oakleigh, Noble Park, and Hawthorn (Melbourne, Australia)
Research Purpose	To evaluate the changes in sarcopenia risk factors (muscle mass, strength, and function) as well as Quality of Life among older adults over time while undertaking exercise training.

INFORMATION TO PARTICIPANTS

We would like to invite you to be a part of a study into **"Evaluation of sarcopenia risk factors through exercise training"** (Project no. 25901).

Victoria University is collaborating with Uniting AgeWell on this research project, which aims to evaluate the changes in sarcopenia risk factors (muscle mass, strength, and function) as well as Quality of Life (QoL) among older adults over time while undertaking exercise training. Improved sarcopenia risk factors should reduce the incidence of sarcopenia, with the resultant health benefits.

You are eligible to participate in this research, because you are currently undertaking or approved to undertake the exercise training programs at Uniting AgeWell gyms. If you provide consent, you will be measured at study commencement, six months, and 12 months to assess muscle mass, muscle strength, physical function, and QoL. You will be undergoing similar physical testing to what you would be doing now as part of Uniting AgeWell normal exercise training. There is some risk for cardiovascular events including a heart attack during fitness assessments such as those used in this study (e.g. 400-meter walk). In case of a cardiovascular event, an ambulance will be called. This research study involves exposure to a very small amount of radiation. As part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about 2 millisieverts (mSv) each year. The effective dose from this study is about 0.01 mSv. At this dose level, no harmful effects of radiation have been demonstrated as any effect is too small to measure. The risk is believed to be minimal.

You may not gain anything from participating. However, you will have the opportunity to access clinical body composition scans (DEXA) at no cost (usual cost of $200–$300). You will benefit from an improved understanding of your own body composition, muscle, bone and nutritional health, which will help you maintain independence to perform daily activities.

Your participation is voluntary and non-participation does not in any way alter your involvement with Uniting AgeWell programs or access to resources.

CERTIFICATION BY PARTICIPANT

I, _____
(name)

of _____
(suburb)

training or planning to train at *(please tick)*:

☐ Forest Hill ☐ Hawthorn ☐ Noble Park ☐ Oakleigh

- certify that I am at least 18 years old and that I am voluntarily giving my consent to participate in *Your Muscles Matter* being conducted at Victoria University by Prof. Alan Hayes.
- I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by Ewelina Akehurst
- and that I freely consent to participation involving the below mentioned procedures *(please tick when appropriate)*:

	Yes	No
1. Allow access to my general demographic data (date of birth, gender, cultural background, and health/medical conditions) as well as my body composition and exercise/gym data (data joined, training type, frequency, duration, and intensity) that is stored on the system of Uniting AgeWell gyms.	☐	☐
2. Completing surveys on paper or online.	☐	☐
3. Being tested on physical fitness at a Uniting AgeWell facility.	☐	☐
4. Measurement of body composition via BIA scales and mobile DEXA bus to be located at a Uniting AgeWell facility.	☐	☐
5. I have been involved in any other research studies that involve radiation (if Yes, provide details: type of radiation/date) _____	☐	☐
6. The data that I provide during and after this research may be used by the researchers in future research projects.	☐	☐
7. I would like to receive research findings/reports via hardcopy or email (If Yes, provide your email address): _____	☐	☐

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed: _____

Date: _____

Any queries about your participation in this project may be directed to the researcher:

Chief Investigator: Prof. Alan Hayes
Assistant Dean, Western Centre for Health Research and Education, Institute for Health and Sport, Victoria University and the Australian Institute for Musculoskeletal Science (AIMSS)

(03) 9919 4658 / (03) 8395 8227
0401 692 118
alan.hayes@vu.edu.au
https://www.vu.edu.au/contact-us/alan-hayes

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix G. Information to Participants

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

Uniting AgeWell

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

Title	Evaluation of sarcopenia risk factors through exercise training
Short Title	***Your Muscles Matter***
Project Number	25901
Project Sponsor	Victoria University
Chief Investigator	Prof. Alan Hayes (Victoria University)
Student Researcher	Ewelina Akehurst (Victoria University)
Associate Investigators	Dr David Scott (Monash University) Prof. Sandor Dorgo (The University of Texas at El Paso, USA)
Location	Uniting AgeWell Allied Health and Therapy Centres at Forest Hill, Oakleigh, Noble Park, and Hawthorn (Melbourne, Australia)
Research Purpose	To evaluate the changes in sarcopenia risk factors (muscle mass, strength, and function) as well as Quality of Life among older adults over time while undertaking exercise training.

You are invited to participate

You are invited to participate in a research project entitled **"Evaluation of sarcopenia risk factors through exercise training"** (Project no. 25901).

This project is being conducted by a Student Researcher Ewelina Akehurst as part of a Masters study at Victoria University under the supervision of Prof. Alan Hayes from Institute for Health and Sport.

You are eligible to participate in this research, because you are currently undertaking or approved to undertake the exercise training programs at Uniting AgeWell gyms. Your involvement will contribute to our research. Your participation is voluntary and non-participation does not in any way alter your involvement with Uniting AgeWell programs or access to resources.

Please read this **Information to participants involved in research** in full before deciding whether or not to participate in this research. The **Consent form for participants involved in research** must be completed and placed in the locked box located at the gym reception desk or mailed back in the pre-paid envelope provided.

It is entirely your choice whether you would like to participate, and you can withdraw from the project at any time. There are no costs associated with participating in this research project (other than standard gym fees), nor will you be paid. While we would greatly value

your involvement in this research project, we respect your choice not to be involved. If you choose not to participate in the research, you will still have access to the existing evidence-based assessment, exercise programs and equipment that represent standard practice for Uniting AgeWell strength and exercise services.

Project explanation

Victoria University is collaborating with Uniting AgeWell on this research project, which aims to evaluate the changes in sarcopenia risk factors (muscle mass, strength, and function) as well as Quality of Life among older adults over time while undertaking exercise training. Improved sarcopenia risk factors should reduce the incidence of sarcopenia, with resultant health benefits.

Sarcopenia is associated with age-related loss of muscle mass and strength that can lead to reduced mobility, falls, fractures, loss of independence, and can become life threatening if undiagnosed and untreated. Sarcopenia was formally recognised as a disease in the United States in 2016 and will soon follow in Australia, which will increase awareness, diagnosis, and interest in treatments. Early diagnosis is important as increasing evidence demonstrates therapeutic interventions, particularly resistance training, can improve health and quality of life outcomes for those with or at risk of sarcopenia.

Participating facilities will include Uniting AgeWell Allied Health and Therapy Centres at Forest Hill, Oakleigh, Noble Park, and Hawthorn. Participants will include anyone currently undertaking or approved to undertake the exercise training programs at Uniting AgeWell gyms who provides consent to participate. Research participants will include clients who live at home or in residential care. They will be measured at study commencement, six months, and 12 months to assess muscle mass, muscle strength, physical function, and Quality of Life (QoL). Health-related QoL is a standard to assess a number of dimensions including independent living.

This project is being conducted by Student Researcher Ewelina Akehurst as part of a Masters degree at Victoria University, under the supervision of Professor Alan Hayes, Assistant Dean, Western Centre for Health Research and Education and Victoria University Institute for Health and Sport. Dr David Scott, Senior Research Fellow in the School of Clinical Sciences, Monash University, will also provide research leadership.

The study will be conducted over a 12-month period, commencing in *[XXX – pending ethics approval]*.

What will I be asked to do?

You will be assessed using standardised tests related to: (1) sarcopenia risk and body composition assessments, (2) physical fitness, and (3) QoL. To that aim, you will complete four surveys as well as physical fitness and body composition assessments at intervals: at study commencement, at six months, and at 12 months.

During the period between assessments, you will continue in your own personal exercise program as developed by the Uniting AgeWell exercise physiologist or physiotherapist.

Surveys are expected to take approx. 32 min and physical fitness/body composition assessments approx. 42 min (see Tables 1 and 2). The complete range of tests and measures to be conducted at each time point includes:

Surveys

- Surveys will be available at the gym reception desk and completed on paper or online (Australian Eating Survey online only)
- The Student Researcher will assist with completing surveys on assigned days, as displayed via a poster in the gym.
- Completed surveys can be returned in pre-paid envelopes provided or placed in a locked box located at the gym reception desk.

Table 1: Surveys

No.	Survey	Instrument	Items	Purpose	Completion time
1.	Rapid diagnostic test for sarcopenia	SARC-F	5	Predict sarcopenia risk for poor functional outcomes	2 min
2.	Physical Activity Scale for the Elderly	PASE	10	Assess physical activity status	10 min
3.	Assessment of Quality of Life	AQoL-4D	12	Obtain data on health-related QoL: independent living, mental health, relationships, and senses.	5 min
4.	Australian Eating Survey	AES for adults	15	Assess nutritional adequacy of dietary intake tailored to age, gender, and life stage	15 min
	Total				**32 min**

Physical fitness

- Strength, balance, and other functional tests will be conducted by the Student Researcher and/or Uniting AgeWell exercise physiologists or physiotherapists.
- The tests include the short physical performance battery (SPPB), which is a 5–10 min assessment involving standing balance activities, normal walking speed, and sit-to-stand tests, together with timed up and go, 400-meter walk, and handgrip strength.

Body composition

- The gold standard for body composition, dual energy X-ray absorptiometry (DXA; also called DEXA), will be used to assess lean and fat mass (as well as bone mineral density). A mobile "DEXA bus" will be organised to visit the gyms to undertake this assessment – by a licenced operator.

- DEXA is a non-invasive and quick (4 min) clinical scan (fully clothed) to obtain measures of muscle, bone, and fat mass.
- In addition, your body composition will also be assessed using bioelectrical impedance analysis (BIA) scales located at the gyms. BIA is standard gym practice, but depending on the quality of the BIA device, there can be limitations in lean and fat mass measurements.
- DEXA scans will be cross-checked to verify the BIA measurements as BIA measurements will continue to be used in the gyms in future.

Table 2: Physical fitness and body composition assessments

Component	Test	Equipment used	Completion time/Trials
Balance	Standing balance	Standard or HUR equipment	5 min *(3 different stances with different foot positions)*
Mobility	Walking speed	Stopwatch, measuring tape	5 min *(Walking 4 m 3 times at normal speed; the fastest time will be used for scoring)*
Lower-body muscular endurance	Chair stand (sit-to-stand)	Chair, stopwatch	5 min *(5 chair rises)*
Agility	Timed up and go (TUG)	Chair, cone	5 min *(stand from a chair, walk 3 m, turn around, walk back to the chair, and sit down; 1 practice then 1 trial; the fastest time will be used for scoring)*
Cardiovascular fitness	400-meter walk	Stopwatch, measuring tape, 20 m walking space	10 min *(walk a course of 20 m x 20 times as fast as possible, allowing for two rest stops; 1 trial)*
Upper-body strength	Handgrip strength	Handgrip dynamometer	5 min *(1 practice then 2 trials for both dominant and non-dominant hand; the highest strength of last two will be used for scoring)*
Body composition	BIA	BIA scale	3 min
Body composition	DXA scan	DEXA machine (via DEXA mobile bus)	4 min
Total			**42 min**

What will I gain from participating?

You may not gain anything from participating. However, you will have the opportunity to access clinical body composition scans (DEXA) at no cost (usual cost of $200–$300). You will benefit from an improved understanding of your own body composition, muscle, bone and nutritional health, which will help you maintain independence to perform daily activities, such as showering, dressing, or climbing stairs.

How will the information I give be used?

Access to information. Uniting AgeWell has your demographic as well as current and future body composition and exercise/gym data and will allow Student Researcher and Chief Investigator to access their systems to retrieve relevant data, with your consent. Only the Student Researcher and Chief Investigator will have access to additional data as part of this study, i.e. survey results, physical function, and body composition data obtained via mobile DEXA bus. Information about your participation will be coded with a study code, not your name. Findings from the study will be published and/or presented in a variety of forums and be part of the Student Researcher's final thesis. You will not be identified, and your participation and individual assessment results will remain confidential and secure.

Withdrawing. If you agree to participate but decide to withdraw your consent during the research project, please notify the research team before you withdraw. If you do withdraw during the project, the Student Researcher will not collect additional data about you, although the data already collected will be retained to ensure the results of the research project can be measured properly.

Data storage. During and upon the completion of the project, hardcopies of Consent forms, survey responses, and testing data sheets will be stored in a locked filing cabinet in the Chief Investigator's office (Western Centre for Health Research and Education, Sunshine Hospital, 176 Furlong Rd, St Albans, VIC 3021). The electronic data will be stored in a folder for the project on the Victoria University R drive. After the retention period (five years post publication), the data and materials will be transferred to the Victoria University Research Storage. When further retention of data and materials is no longer required, both digital and hardcopies will be securely destroyed at Victoria University.

Your information will only be used for the purpose of this research project. After completion of this project, your data may be used for an ongoing or larger project. This would only occur following an ethics amendment, with your consent.

What are the potential risks of participating in this project?

All forms of exercise have a risk of injury. The exercise testing and ongoing exercise participation will be fully supervised by exercise physiologists or physiotherapists at each site. In the unlikely event of injury, first aid will be provided. There is some risk for cardiovascular events including a heart attack during fitness assessments such as those used in this study (e.g. 400-meter walk). In case of a cardiovascular event, an ambulance will be called. If an injury occurs during testing that requires medical intervention, this will be at the expense of the Researchers.

This research study involves exposure to a very small amount of radiation. As part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about 2 millisieverts (mSv) each year. The effective dose from this study is about 0.01 mSv. At this dose level, no harmful effects of radiation have been demonstrated as any effect is too small to measure. The risk is believed to be minimal.

Have you been involved in any other research studies that involve radiation? If so, please tell us. Please keep information contained within the Information for participants and Consent form about your exposure to radiation in this study, including the radiation dose, for at least five years. You will be required to provide this information to researchers of any future research projects involving exposure to radiation.

How will this project be conducted?

The ethics approval to conduct this research has been sought from the Victoria University Human Research Ethics Committee (VUHREC). Following your written consent, you will be asked to complete surveys. You will be notified of assessment dates for physical fitness and body composition via a poster, displayed in the gym.

Standardised physical fitness testing will be conducted by the Student Researcher and/or Uniting AgeWell exercise physiologist or physiotherapist. Body composition will be measured via BIA scales and mobile DEXA bus, which will be located at a Uniting AgeWell facility (see Table 2).

Your data will be collected at study commencement, at 6 months, and 12 months. You will also receive individualised reports from completing the Australian Eating Survey and DEXA scans. You can receive a copy of research finding if you provide us with your details on the Consent form.

Who is conducting the study?

Victoria University is conducting the study with Uniting AgeWell. The following staff are involved:

Victoria University

Professor Alan Hayes
Chief Investigator
Assistant Dean, Western Centre for Health Research and Education, Victoria University Institute for Health and Sport and the Australian Institute for Musculoskeletal Science
Phone: 0401 692 118
Email: alan.hayes@vu.edu.au
https://www.vu.edu.au/contact-us/alan-hayes

Ewelina Akehurst
Masters Student Researcher
Victoria University Institute for Health and Sport
Phone: 0406 786 051
Email: ewelina.akehurst@live.vu.edu.au

Amanda Mehegan
Project Manager, Uniting AgeWell
Phone: 0448 897 810
Email: amehegan@unitingagewell.org
www.unitingagewell.org

Any queries about your participation in this project may be directed to the Chief Investigator listed above. If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix H. Key Dates Poster

Key dates for participants

Surveys	Physical assessments	Body composition assessments
Collect your survey pack from Uniting AgeWell admin. Please complete and return to staff, or via return mail, by:	Participants will be booked in for assessments on these days:	A specialist clinical bus will be located at this site to conduct the DEXA scans on: ....

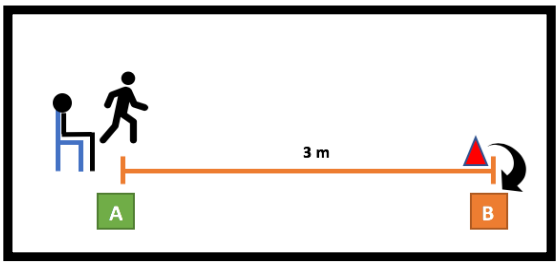
VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

Uniting AgeWell

Appendix I. TUG Assessment/Scoring Sheet

3.3 Timed Up & Go (TUG)

Figure 10. TUG



Purpose: to assess mobility and balance
Walking speed: normal

Equipment

1. Tape measure (3 m)
2. Coloured tape to identify start (A) and finish lines (B).
3. Stable chair with armrests
4. Cone
5. Stopwatch
6. Clipboard and pen
7. TUG assessment/scoring sheet

Preparation

1. Place a sign "Assessment in progress" to avoid people interrupting the test.
2. **A straight, level, and free of obstruction course 3 m in length should be used.**
3. Surface should be non-slippery and flat for safe walking and to minimise trip hazards.
4. Place a piece of coloured tape at two spots on the floor:
   a. at the start line
   b. at the finish line, which is the end of 3 metres from the start line.
5. Place a chair at the start of the course and a cone at the finish line.
6. The back of the chair should be against a wall or table to prevent the chair from falling backwards.
7. Reset stopwatch to '0:00'.

Directions

1. Subject will perform one practice trial and two recorded trials of standing up from a chair, walking across the 3-metre course at your normal speed, turning around the cone, returning to the chair, and sitting down.
2. Subject can have a short rest between trials if needed (up to 30 sec).
3. Subjects wear their regular comfortable clothes and footwear.
4. The test should be conducted without a walking aid, but it is allowed If needed.
5. Tester should read the script in ***green bold italics*** for consistency among subjects and gyms.
6. Subject will be sitting in a chair to listen to the instructions.

Instruct subject:

1. ***This is timed-up-and-go test to assess your mobility and balance. I want you to sit down in a chair. If you usually use a walking aid, you may use it for the test. I will be timing you with a stopwatch.***
2. ***When I say, "GO", I want you stand up from the chair. You may use the arms of the chairs to stand up or sit down.***
3. ***Once you are up, you should walk, without stopping, at your normal speed, until you pass that cone. Turn around.***
4. ***Walk back to the chair and sit down again.***
5. ***Please watch while I demonstrate*** (demonstrate).
6. Stand up from a chair. Keep your head up and walk with good posture at normal fast pace past the cone, turn around, come back quickly and sit back down.
7. ***You will do the test three times. The first one is practice and the other two are recorded trials.***
8. ***Do you feel this test will be safe for you to do?*** (If YES, continue with instructions; if NO, complete *No attempt/discontinuation* and *Observations boxes*).
9. ***Do you have any questions?*** (If YES answer questions, if NO start the test).

Trial 1 (practice)

1. ***Are you ready? Remember to stand up, walk at your normal speed, turn around, come back and sit down again.***
2. ***READY, SET, GO!***
3. Start timing (press the START button to start the stopwatch) as subject begins to stand up.
4. Stop timing after subject sits back down.
5. ***Nicely done. How do you feel?***
6. If subject did not attempt the test or failed, complete *No attempt/discontinuation* and *Observation* boxes.
7. If subject needs a rest before the next trial, they can rest up to 30 sec.
8. Record the time for Trial 1 (practice) on the scoring sheet.
9. Reset the stopwatch to '0.00' before subject begins Trial 2.

Trial 2

1. ***Are you ready to do the test again? Remember to walk at your normal speed.***
2. ***READY, SET, GO!***
3. Press the START button to start the stopwatch as subject begins standing up.
4. Stop timing after subject sits back down.
5. ***Nicely done.***
6. If subject needs a rest before the next trial, they can rest up to 30 sec.
7. Record the time for Trial 2 on the scoring sheet.
8. Reset the stopwatch to '0.00' before subject begins the final trial.

Trial 3

1. ***Are you ready to do the test for the last time? Remember to walk at your normal speed.***
2. ***READY, SET, GO!***
3. Press the start button to start the stopwatch as subject begins standing up.
4. Stop timing after subject sits back down.
5. ***Congratulations. You have completed the test. How do you feel?***
6. Record the time for Trial 3 on the scoring sheet.
7. Reset the stopwatch to '0.00'.

Timed Up & Go (TUG)

Assessment

Subject/Tester info

Forest Hill ☐ Hawthorn ☐ Noble Park ☐ Oakleigh ☐

Subject Date of birth (DD/MON/YYYY): ____/____/_____

Subject initials: _____

Tester initials: _____

Date of Assessment (DD/MON/YYYY): ____/____/_____

Time Assessment started: ____:____ ☐ AM ☐ PM

Scoring sheet

Trial	Time (sec)
Trial 1 (practice)	_____ - _____
Trial 2	_____ - _____
Trial 3	_____ - _____
Lowest time from Trials 1, 2 and 3	

Other comments

_____

_____

No attempt/discontinuation
If subject did not attempt test or failed. **Check all that apply:**

- ☐ 1. Tried but unable
- ☐ 2. Subject could not hold position unassisted
- ☐ 3. Not attempted, tester felt unsafe
- ☐ 4. Not attempted, subject felt unsafe
- ☐ 5. Subject unable to understand instructions
- ☐ 6. Other (specify) _____
- ☐ 7. Subject refused

Observations

Observe the client's postural stability, gait, stride length, and sway. **Check all that apply:**

- ☐ Slow tentative pace
- ☐ Loss of balance
- ☐ Short strides
- ☐ Little or no arm swing
- ☐ Steadying self on walls
- ☐ Shuffling
- ☐ En bloc turning (rigid neck/upper body when turning)
- ☐ Using walking aid
  - ☐ single-point cane
  - ☐ multi-point cane
  - ☐ crutch
  - ☐ other (specify) _____
- ☐ Not using walking aid properly
- ☐ Fall during test
- ☐ Injury during test
- ☐ If injury occurred during test, Incident Protocol was completed.

Appendix J. Physisist Report

16th November 2018

Victoria Earl
Consultant Medical Physicist
BSci (Hons), MMedPhys
Approved medical physicist in diagnostic radiology and nuclear medicine for the purposes of the Code[1]

Tel. No.: 0404 813 283
Email: vjearl78@gmail.com

Victoria University Human Research Ethics Committee
Victoria University
PO Box 14428
Melbourne VIC 8001

Dear Victoria University Human Research Ethics Committee

Re: ***HREC No.:*** 25901 (Amendment)
Title: Evaluation of sarcopenia risk factors through exercise training
Principal Investigator: Prof. Alan Hayes

Participant Information
Age: ≥60 years **Gender:** male and female
Life expectancy: >5 years **No. at Victoria University:** >80
Duration of participation in research
Average Transit Time: 12 months
Maximum Transit Time: 12 months

The Radiation Team, Victorian Department of Health and Human Services (DHHS) stipulates compliance with the Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes[1] and the DHHS guidance on risk statements[2]. For projects in which the research participant receives an exposure to ionising radiation beyond that considered normal care of the condition being treated, the Code requires an independent dose assessment be undertaken by a medical physicist.

This study is investigating the changes in sarcopenia risk factors as well as quality of life among older adults over time while undertaking exercise training. This report is for the amended protocol which has removed the peripheral quantitative computed tomography (pQCT) scans from the schedule of assessments and has limited the Dual Energy X-ray Absorptiometry (DEXA) scan assessments to one imaging site. The initial Medical Physics report for this project was issued on the 25th September 2018.

The project requires that the volunteer participants undergo the following imaging that may involve ionising radiation exposure:

- DEXA scan of the whole body for the assessment of body composition at baseline, six months and 12 months.

The imaging involves radiation exposure that is not standard care for these participants. The DEXA scan will be undertaken using a Hologic Horizon A on the Measure Up mobile DEXA bus. The Hologic Horizon A incorporates a fan beam with switched-pulse dual energy of 100 kVp and 140 kVp and GADOX scintillator detectors.

The estimated effective dose[3-4] for a whole body DEXA scan on the Hologic Horizon A is approximately 0.004 millisieverts (mSv). The total effective dose received by each participant for imaging that is not part of their standard care will be approximately 0.01 mSv.

The Code specifies dose constraints, which should be met wherever possible, for radiation exposure that is **additional** to standard care. The total effective dose for adults should not exceed 5 mSv in any one year or 10 mSv over five years. Furthermore, when all participants are aged 60 years or more the dose constraint is 8 mSv in any one year and 16 mSv over five years[2] and when all participants are aged 70 years or more it increases to 12 mSv in any year and 24 mSv over five years[2]. Participants with a life expectancy of less than five years can receive up to 50 mSv per year. Conversely, the constraint for children (to 18 years) is 0.5 mSv per year with a maximum limit during childhood of 5 mSv.

For projects in which the dose constraints are exceeded, the Ethics Committee should give particular attention to the justification for the radiation exposure, and if necessary, seek further independent authoritative advice before approving the proposal. Furthermore, where the dose constraints are exceeded, verification of the dose assessment must be obtained from a second medical physicist.

In this project, all participants are listed as being over 60 years of age. The total effective dose of approximately 0.01 mSv does not exceed the dose constraint of 8 mSv per year. This radiation dose falls within Category I, which represents a **minimal** level of risk.

Recommendations

In summary, the following recommendations and comments are made:

1. Victorian Medical Physics Risk Assessment Form (MPRA)

   As this research will be conducted under the authorisation on the Victoria University Radiation Management Licence, the representative of this Licence has completed Appendix 1.7a of the MPRA. As some imaging will be undertaken at Measure Up mobile DEXA bus, the representatives of the other site Radiation Management Licences has completed Appendix 1.7b of the MPRA.

2. Participant Information and Consent Form (PICF), Risk Statement

   An information statement, such as the following, must be included in the information provided to the research participants:

   > *This research study involves exposure to a very small amount of radiation. As part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about 2 millisieverts (mSv) each year. The effective dose from this study is about 0.01 mSv. At this dose level, no harmful effects of radiation have been demonstrated as any effect is too small to measure. The risk is believed to be minimal.*
   >
   > *Have you been involved in any other research studies that involve radiation? If so, please tell us. Please keep information contained within the Patient Information and Consent Form about your exposure to radiation in this study, including the radiation dose, for at least five years. You will be required to provide this information to researchers of any future research projects involving exposure to radiation.*

   Please amend the text on page 5 of the PICF (version 1) to reflect the above.

   Note to researchers:

Note to researchers:

Please note that the information to be provided to the participants (as stated in italics above) is not exhaustive and is intended to prompt a dialogue between participants and researchers regarding the risks of radiation exposure. Researchers should be in a position to have some knowledge of the risks of ionising radiation or be able to refer participants to someone who can provide advice.

3. Notification of the Radiation Team, Victorian Department of Health and Human Services (DHHS)

   This research project involves exposure of human volunteers to ionising radiation in addition to standard clinical care, which **does not exceed** the dose constraints specified in the Code[1]. Notification of DHHS is not required for this project.

Please do not hesitate to contact me if you require further information.

Yours sincerely

[redacted]

Victoria Earl

Consultant Medical Physicist*

**Approved by the Radiation Team, Victorian Department of Health and Human Services as a medical physicist in diagnostic radiology and nuclear medicine for the purposes of the Code[1].*

References

1. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes, Radiation Protection Series (RPS) 8 (2005).
2. Radiation Safety Section, Victorian Department of Health and Human Services, Standard Radiation Risk Statements, April 2015.
3. Blake G.M., Naeem M. and Boutros M., *Comparison of effective dose to children and adults from dual X-ray absorptiometry examinations*, Bone 38 (2006) 935–942.
4. Correspondence from Thomas L. Kelly (Senior Principal Scientist, Radiation Safety Officer, Hologic, Inc.).

Appendix K. Tanita Dual Frequency Body Composition Analyser DC-360S

Wedderburn®
Do More.

Tanita Dual Frequency Body Composition Analyser

Model : TIDC360S

Featuring Dual Frequency BIA technology, the TIDC360S delivers full body composition analysis in 15 seconds. Results are instantly shown on the easy-to-read LCD screen & the integrated printer automatically prints the body composition measurements together with a top line analysis. The robust, low profile platform provides additional client stability.

For large data collection & convenience, all data can be stored on the SD Card for future use. Compatible with GMON Pro Software, the TIDC360S allows client trend analysis, health risk assessments and full data management.

FEATURES	TIDC360S
• dual frequency for more accurate measurement results	
• whole body composition analysis available in 15s	
• automatic result printout with integrated thermal printer	
• data can also be transferred through to PC via USB port & SD card (CSV format), allowing large anonymous data sets to be collated for research studies	
• wide low-level platform making it easy to step on	
• light weight and easily transportable	
• athlete mode	

MEASUREMENTS INCLUDE:

✓Body Weight	✓Body fat %	✓Fat mass
✓Fat free mass	✓Muscle mass	✓total body water %
✓total body water kg	✓BMI	✓Bone mass
✓Physique rating	✓BMR	✓Metabolic age
✓Desirable range indicator		

SPECIFICATIONS:

Platform size (mm):	390 (W) x 395 (D) x 67 (H)
Capacity:	270kg x 100g
Net weight:	8.3kg

Weighing Scales.

Labels. Packaging Equipment. Weighing Scales. POS Systems. Food Equipment. Maintenance & Repairs. Hire.

Phone: 1300 970 111

enquiries@wedderburn.com.au

wedderburn.com.au

Appendix L. Jamar Plus+ Digital Handgrip Dynamometer

SI Instruments—test equipment for

Occupational Health and Safety

Jamar® Plus+ Digital Hand Dynamometer

Ideal for routine screening of grip strength and initial and ongoing evaluation of clients with hand trauma and dysfunction. Sturdy aluminum body construction with scratch resistant UV coating. The readout displays isometric grip force from 0- 200 lbs. (90 kg.). The unit's easy-to-read LCD display can be set to display pounds or kilograms. The dynamometer also features digital load cell technology, Rapid Exchange Testing with audible signals, and automatically calculates the Average, Standard Deviation, and Coefficient of Variation. Two minute auto-off feature helps conserve battery power. Battery low life indicator. Requires two AAA batteries included. Comes in a sturdy carrying case.

Hand dynamometers

Routine screening and evaluation of grip strength measurement….

Pinch gauge

Accurate and repeatable pinch strength readings….

Manual muscle tester

Objective, reproducible & reliable muscle strength measurement….

Inclinometer

Determine range of motion as referenced from the body's natural position….

Spirometer

Incentive exerciser for respiratory problems….

Dexterity tests

Test dexterity and coordination of finger tip dexterity & visual motor coordination….

Measurement tape

Accurate and repeatable measurement….

SI Instruments Pty Ltd

GPO Box 1530, Adelaide, SA, 5001
256 South Road, Hilton, SA 5033 AUSTRALIA

www.si-instruments.com
Email: info@si-instruments.com
Phone: +61 (0) 8 8352 5511
Fax: +61 (0) 8 8352 6011

Appendix M. Sports Stopwatch XCO270

jaycar

Search keyword or product code

PRODUCTS CATALOGUES STORE FINDER NERD PERKS

Sports Stopwatch

CAT.NO: **XC0270**

This handy 1/100th of a second sports timer will be a useful addition to any sports bag.

Share |

ADD TO WISHLIST

Shipping & Delivery Information

DESCRIPTION SPECIFICATIONS DOWNLOADS

This handy 1/100th of a second sports timer will be a useful addition to any sports bag. Not only does it measure elapsed time for up to 24hrs, our water resistant stopwatch has a split time (Lap) function as well as alarm and calendar functions.

Appendix N. AES Guidelines

The Australian Eating Surveys:
Food Frequency Questionnaires for
Pre-schoolers, Children, Adolescents and Adults

Guidance on Food and Nutrition

Intake Output

A partnership between researchers at The University of Newcastle and Newcastle Innovation.

Enquiries and Technical Support

Email: EatingSurvey@newcastle.edu.au

Contents

Nutrients assessed

The nutrients assessed by the AES FFQ are listed in the table below.

Table 1: Nutrient data provided by the AES FFQ

Energy (kJ)	Carbohydrates (g)	Niacin eqv (mg)	Magnesium (mg)
Protein (g)	Sugars (g)	Vitamin C (mg)	Calcium (mg)
Total fat (g)	Fibre (g)	Folate (µg)	Iron (mg)
Saturated fat (g)	Thiamin (mg)	Vitamin A (µg)	Zinc (mg)
Polyunsaturated fat (g)	Riboflavin (mg)	Retinol (µg)	Alcohol (g)
Monounsaturated fat (g)	Niacin (mg)	Betacarotene (µ)	

Calculation of nutrient data

Nutrient intake is only calculated for complete surveys. The nutrient data from the AES FFQ is computed using FoodWorks (Version 3.02.581) utilising the Australian AusNut 1999 database (All Foods) Revision 14 and AusFoods (brands) Revision 5. Portion sizes for the AES FFQ were determined using the 'natural' serving size (e.g. slice of bread) where possible. In the absence of a natural serving size, portion size data from the 1995 NNS was used (unpublished data purchased from the ABS). There were eight items without a 'natural' serving size or NNS data. For these foods, either FoodWorks 'Unspecified' serve sizes were used (5 items) or packet serve sizes (3 items). For composite items (those including more than one food), the NNS data was used and weighted according to the NNS consumption data, so that foods consumed by the largest numbers of this age group were weighted more heavily.

In order to analyse food intake in terms of frequency, responses are converted to daily equivalent frequencies and calculated against portion sizes for populations. Questions concerning alcohol consumption have been included in the AES FFQ. Please note that alcohol questions were not included in the comparative validation of the AES FFQ because insufficient participants indicated they had consumed alcohol to enable statistical analysis.

Format of output files

You will receive one **Dataset** file in the statistical package of your choice. The dataset contains the analysed data in addition to how your respondents answered individual questions. The dataset is ordered in rows for each survey assigned, with the unique Participant ID number used for identification of individual FFQs.

Data included within this dataset:

- Total energy, macronutrient and micronutrient intakes
- Percentage of energy contributed to total energy intake by:
    - Macronutrients (protein, carbohydrate, fats, alcohol)
    - Core and non-core foods (see Appendix 1 for groupings)
- Australian Recommended Food Score
- Responses to individual questions (provided for all surveys, regardless of stage of completion).

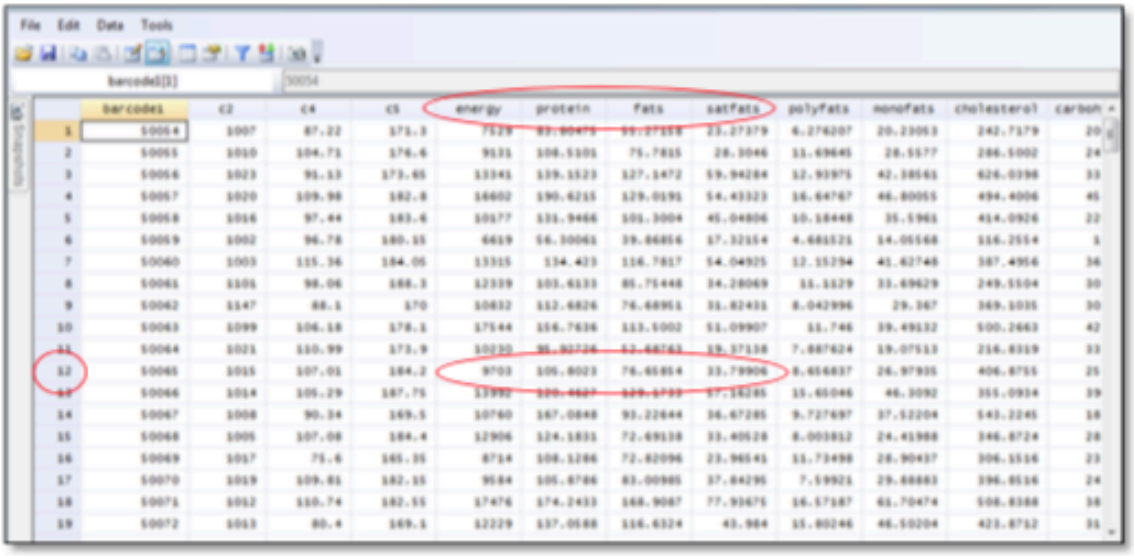
Handling missing data

Missing responses are coded as "99" in the data sheet. The "99" code is not included in the analysis, and hence it is important individual questionnaires are checked for missing responses. Nutrient intake is not calculated for incomplete surveys.

How to read your data

Variables given

When you first open your data file, you will see the following variables:



	barcodes	c2	c4	c5	energy	protein	fats	satfats	polyfats	monofats	cholesterol	carbon
1	10054	1007	87.22	171.3	7529	[illegible]	[illegible]	23.27379	6.276207	20.23053	242.7179	20
2	10055	1010	104.71	176.6	9131	108.5101	75.7815	28.3046	11.69641	28.5577	286.5002	24
3	10056	1023	91.13	173.65	13341	139.1523	127.1472	59.94284	12.93975	42.38561	626.0398	33
4	10057	1020	109.98	182.8	16602	190.6215	129.0191	54.43323	16.64767	46.80055	494.4006	45
5	10058	1016	97.44	183.6	10177	131.9466	101.3004	45.04806	10.16448	35.1961	414.0926	22
6	10059	1002	96.78	180.15	6619	56.30061	39.86856	17.32154	4.681521	14.05568	116.2554	1
7	10060	1003	115.36	184.05	13315	134.423	116.7817	54.04925	12.15254	41.42746	387.4956	36
8	10061	1101	98.06	188.3	12339	103.6133	85.75448	34.28069	11.1129	33.69629	249.5504	30
9	10062	1147	88.1	170	10832	112.6826	76.68951	31.82431	8.042996	29.367	369.1035	30
10	10063	1099	106.18	178.1	17544	156.7636	113.5002	51.09907	11.746	39.49132	500.2663	42
11	10064	1021	110.99	173.9	10230	[illegible]	[illegible]	19.37138	7.887624	19.07513	216.8319	33
12	10065	1015	107.01	184.2	9703	105.8023	76.65854	33.79906	8.616837	26.97935	406.8755	25
13	10066	1014	105.29	187.75	13992	[illegible]	[illegible]	57.18285	11.65046	46.3092	355.0934	39
14	10067	1008	90.34	169.5	10760	167.0848	93.22644	36.67285	9.727697	37.12204	143.2245	18
15	10068	1005	107.08	184.4	12906	124.1831	72.69138	33.40528	8.003812	24.41988	146.8724	28
16	10069	1017	75.6	165.35	8714	108.1286	72.82096	23.96141	11.73498	28.90437	306.1516	23
17	10070	1019	109.81	182.15	9584	105.8786	81.00985	37.84295	7.59921	29.88883	396.8516	24
18	10071	1012	110.74	182.55	17476	174.2433	168.9087	77.93675	16.57187	61.70474	508.8388	38
19	10072	1013	80.4	169.1	12229	137.0588	116.6324	43.984	15.80246	46.59204	423.8712	31

Figure 1: Data first seen upon opening the data set.

Please note that examples below are as seen in Stata format. The format of the data supplied will vary according to statistical program selected.

Example as shown in Figure 1: Row 12 shows the participant consumed a daily average of 9703kJ of energy and approximately 106g of protein. Of the 77g of fat consumed by this participant, 34g were saturated.

Participant ID

This is unique identifier that you assigned to each survey at the time of administration.

Nutrient data

	energy	protein	fats	satfats	polyfats	monofats
19	12229	137.0588	116.6324	43.984	15.80246	46.50204
20	20266	172.6511	183.9126	94.91323	12.90262	62.47431
21	13596	129.4733	108.7464	46.75607	12.55446	39.71425
22	6902	102.9239	61.41156	22.65019	8.577762	23.82601
23	7558	74.5691	53.90223	22.52056	5.970867	20.2397
24	15945	156.5812	114.1909	50.58806	12.25469	41.9458

Figure 2: Nutrient data

Nutrient data variables are found after information that identifies each participant. The measurement units for each nutrient are shown in **Table 1** on page 2. These nutrient values are used to generate the percentage energy (PE) contributions of macronutrients to total diet (see Figure 2). Data is given as a daily average.

Macronutrients

	peprotein	pecarbohyd~e	pefats	pesatfats	pepolyfats	pemonofats
19	19	44	37	14	5	15
20	15	51	35	18	2	12
21	16	49	31	13	4	11
22	25	36	35	13	5	13
23	17	35	28	12	3	10
24	17	47	28	12	3	10
25	19	42	37	15	4	14

Figure 3: Macronutrient contributions to total energy.

The macronutrients are converted to a percentage of total energy, to allow for easier comparisons to dietary targets such as the Acceptable Macronutrient Distribution Range (AMDR)or recommendations such as saturated fat <7% for optimal heart health. This variable can be identified by the name containing "pe", represents "percentage energy" with the macronutrient also in the name. *Example as shown in **Figure 3***: Row 23 shows "peprotein" to be 17, which means that for this participant, protein contributes 17% of the energy of their total diet. This may then be directly compared to the AMDR.

	pfmonofats	pfpolyfats	pfsatfats
50	41	12	47
51	41	14	45
52	40	12	48
53	40	12	47
54	45	15	40

Figure 4: Total fat energy by mono- poly- and saturated fat types.

The "pf" prefix designates the variable as an energy percentage of total fat. The rest of the variable name is the type of

fatty acid (monounsaturated, polyunsaturated and saturated). As an example, in Figure 4,line 50 shows 41% of fat intake to be from monounsaturated fat types, 12% from polyunsaturated fat and 47% from saturated fats.

Percentage energy from food groups

	peveg	pefruit	pemeat	pealt	pegrains
1	14	0	16	3	16
2	13	16	16	3	15
3	10	4	11	3	19
4	7	3	8	3	22
5	5	6	22	2	16
6	14	2	4	0	21
7	2	1	10	1	12

Figure 3: Percentage energy values for core and non-core food groups.

The "pe" prefix once again refers to percentage energy. This is a conversion of the energy values for the food groups as shown in **Figure 5** to a percentage of total energy. The participant on line 1 had an energy value for vegetables of 1068kJ, which converts to 14% of their daily energy intake. *Please note that these values are rounded to whole integers.*

Australian Recommended Food Score

	arfs	arfs_veg	arfs_fruit	arfs_meat
1	26	15	0	2
2	52	16	10	6
3	41	20	3	3
4	45	15	5	4
5	38	14	7	3
6	15	9	1	1

Figure 4: Australian Recommended Food Scores (ARFS) and the contributing groups.

The Australian Recommended Food Scores are shown in this figure. The variable labelled arfs is the total food score, and the variables following it are the contributing groups.

Calculation of Australian Recommended Food Score (ARFS)

The ARFS is validated in the following papers:

- Marshall S, Watson J, Burrows T, Guest M, Collins CE. The development and evaluation of the Australian Child and Adolescent Recommended Food Score: a cross-sectional study. Nutrition Journal. 2012 Nov 19; 11(1):96.
- Burrows TL, Collins K, Watson JF, Guest M, Boggess MM, Hutchesson MJ, Rollo M, Duncanson K, Collins CE. Validity of the Australian Recommended Food Score as a diet quality index for Preschoolers. Nutrition Journal 2014, 13:87.
- Collins CE, Burrows TL, Rollo ME, Boggess MM, Watson JF, Guest M, Duncanson K, Pezdirc K, Hutchesson MJ. The comparative validity and reproducibility of a diet quality index for adults: the Australian Recommended Food Score. Nutrients 2015, 7(2), 785-798.

The highest food scores possible are given in Table 2 below:

Table 2: Food groups and possible scores contributing to the Australian Recommended Food Score

Australian Recommended Food Score (ARFS)	Total score available
Total	***73***
Vegetables	21
Fruit	12
Protein foods – Meat/flesh	7
Protein foods – Meat/flesh alternatives	6
Grains, breads and cereals	13
Dairy	11
Water	1
Extras	2

Appendix 1: FFQ questions contributing to energy intake as core and non-core food groups

CORE GROUPS
Breads and Cereals
Muesli
Cooked porridge
Breakfast cereal
Brown bread/pita/roll/toast/other bread, not sure
Muffin/bagel/crumpet
Rice
Other grains
Noodles
Pasta
Fruit
Canned fruit
Fruit salad
Dried fruit
Apple or pear
Orange, mandarin, grapefruit
Banana
Peach, nectarine, plum, apricot
Mango or paw paw
Pineapple
Grapes, strawberries, blueberries
Melon
Vegetables and salad
Potato
Pumpkin
Sweet potato
Cauliflower
Green beans
Spinach
Cabbage or brussel sprouts
Peas
Broccoli
Carrots
Zucchini, eggplant, squash
Capsicum
Corn, sweetcorn, corn on the cob
Mushrooms
Tomatoes
Lettuce
Celery, cucumber
Avocado
Onion, spring onion, leek

Dairy and alternatives
Flavoured milks and alternatives
Plain milks and alternatives
Yoghurt not frozen
Cottage cheese, ricotta
Cheese
Cheese spread, cream cheese
Meat and alternatives
Mince dish
Beef/lamb pieces in sauce, NO vegetables
Plain meat (beef/lamb), NO vegetables
Chicken pieces in sauce, NO vegetables
Plain chicken WITHOUT vegetables
Pork pieces in sauce WITHOUT vegetables
Plain pork WITHOUT vegetables
Beef/lamb with vegetables
Plain meat with vegetables or salad
Chicken pieces with vegetables
Plain chicken with vegetables
Pork pieces with vegetables
Plain pork with vegetables
Liver
Fresh fish
Canned tuna, salmon, sardines
Other seafood
Nuts
Eggs
Soybeans, tofu
Baked beans
Other beans, lentils
Miscellaneous
Tea or coffee

Non-core	Subgroups
Soft drink (not diet) Fruit juice drinks Cordial Cream or sour cream Ice cream Frozen yoghurt Cakes, muffins, scones Sweet pie or pastry Other puddings & desserts Plain sweet biscuits Cream or chocolate biscuits Savoury biscuits Savoury combination snacks Sweet combination snacks Snack noodles Fruit bars Snack bars Muesli bars Chicken, crumbed Fish, crumbed or battered Creamy soup Clear soup Tacos, burritos and enchiladas Sausages, frankfurts and Pluto Pups Hamburger, all types Pizza Pie, sausage roll, chiko roll Hot dog Savoury pastries Hash browns, potato scallops Chips, not potato Potato chips or crisps Ice-blocks, creamy Ice-blocks, water Chocolate Lollies without chocolate Low fat salad dressing or mayonnaise Jam, honey, golden syrup, marmalade Peanut butter, Nutella Vegemite Tomato & barbecue sauce Devon, salami Bacon, ham Jelly Hot chips from shop Hot chips at home	**Sweetened Drinks** Soft drinks, fruit juice and cordials **Packaged Snacks** Savoury combinations, sweet combinations, snack noodles, fruit bars, snack bars, muesli bars, twisties, potato crisps **Confectionery** Cream, ice cream, frozen yoghurt, creamy ice blocks, water ice blocks, chocolate, lollies, jelly **Baked sweet products** Cakes, sweet pastries, puddings, sweet biscuits, cream biscuits **Fried/Takeaway** Crumbed chicken, crumbed fish, tacos, hamburgers, pizza, pies, hot dog, savoury pastries, hash browns, takeaway fries, home fries **Spreads & sauces** Low fat dressings, mayonnaise, jam, peanut butter, vegemite, tomato sauce **Fatty meats** Sausages, devon, bacon **Alcohol** Beer, wine or wine coolers, spirits **Miscellaneous** Clear soup, creamy soup

Notes on the Groupings

Diet soft drink is not displayed in the report graph due to negligible energy content

Miscellaneous foods

The nutrient profile of 'clear soup' and 'creamy soup' best reflects those in the non-core foods, whereas the nutrient profile of 'tea or coffee' best reflects foods in the core group. However, in the effort of reducing the number of groups displayed in the core and non-core intake report graph and due to the very small amount of energy contributed by 'tea or coffee' to overall energy intake, this food is grouped with the other 'non-core' miscellaneous for the percentage contribution to total energy intake.

Appendix O. DEXA Report

<Last name, First name> **<Age: 84>**
<DOB>

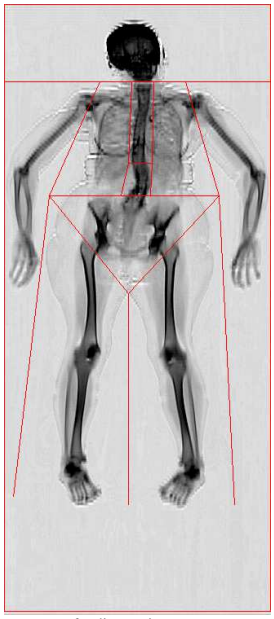


Image not for diagnostic use
327 x 150

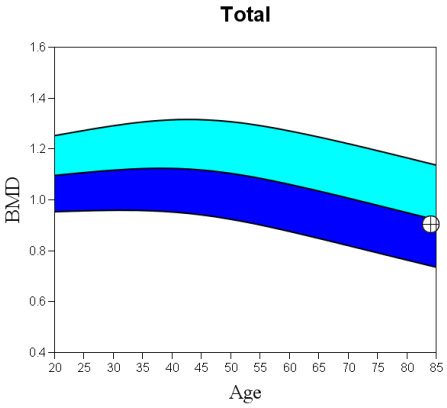
Scan Information:

Scan Date: 17 May 2019 ID: A0517190B
Scan Type: a Whole Body
Analysis: 17 May 2019 10:38 Version 13.6.0.2
Model: Horizon A (S/N 201027)
Comment:

DXA Results Summary:

Region	Area (cm²)	BMC (g)	BMD (g/cm²)
L Arm	177.97	102.11	0.574
R Arm	173.23	89.97	0.519
L Ribs	95.89	46.25	0.482
R Ribs	80.89	41.24	0.510
T Spine	116.80	97.13	0.832
L Spine	43.41	54.56	1.257
Pelvis	154.29	159.10	1.031
L Leg	291.61	248.12	0.851
R Leg	287.67	242.59	0.843
Subtotal	1421.77	1081.05	0.760
Head	199.28	382.90	1.921
Total	**1621.05**	**1463.95**	**0.903**

TBAR1390



T-score vs. White Female. Source:2012 BMDCS/NHANES. Z-score vs. White Female. Source:2012 BMDCS/NHANES.

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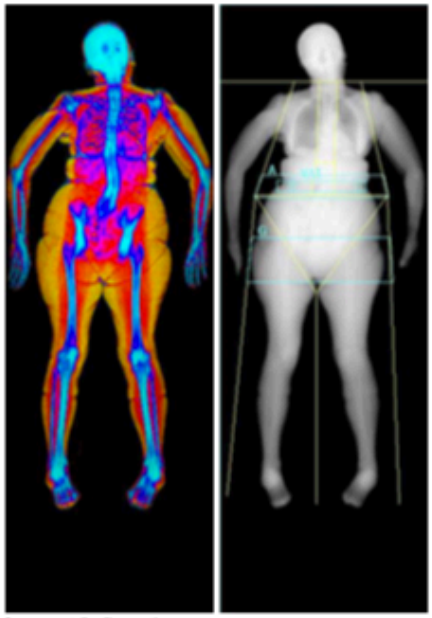
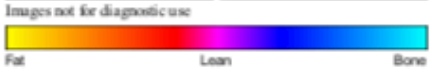
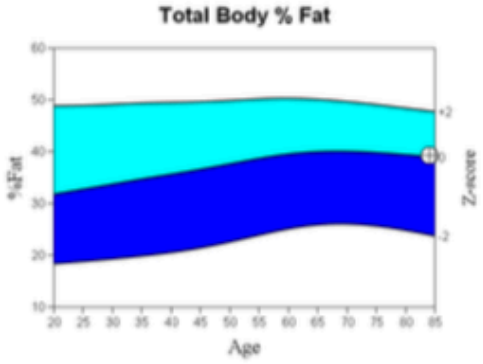
MeasureUp
Level 1, 115 Pitt Street
Sydney, NSW 2000

Telephone: (02) 8821 7111 E-Mail: info@measureup.com.au Fax: (02) 8821 7112



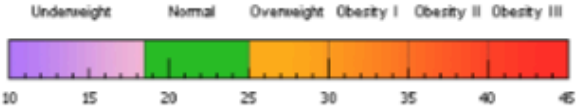
Images not for diagnostic use





Source: NHANES Classic White Female.

World Health Organization Body Mass Index Classification
BMI = WHO Classification



BMI has some limitations and an actual diagnosis of overweight or obesity should be made by a health professional. Obesity is associated with heart disease, certain types of cancer, type 2 diabetes, and other health risks. The higher a person's BMI is above 25, the greater their weight-related risks.

Body Composition Results

Region	Fat Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat	%Fat Percentile YN	AM
L Arm	1621	1369	2989	54.2	97	90
R Arm	1394	1389	2782	50.1	93	71
Trunk	8415	17658	26073	32.3	63	23
L Leg	4333	4868	9202	47.1	90	72
R Leg	4573	4471	9044	50.6	96	86
Subtotal	20335	29755	50090	40.6	80	53
Head	874	3038	3912	22.3		
Total	**21209**	**32793**	**54002**	**39.3**	**80**	**52**
Android (A)	1140	2643	3783	30.1		
Gynoid (G)	3919	5135	9054	43.3		

Scan Date: 17 May 2019 ID: A051719081
Scan Type: a Whole Body
Analysis: 17 May 2019 10:38 Version 13.6.0.2
Model: Horizon A (S/N 210027)
Comment:

Adipose Indices

Measure	Result	Percentile YN	AM
Total Body % Fat	**39.3**	**80**	**52**
Fat Mass/Height^2 (kg/m^2)	10.2	69	48
Android/Gynoid Ratio	0.70		
% Fat Trunk/% Fat Legs	0.66	31	10
Trunk/Limb Fat Mass Ratio	0.71	39	17
Est. VAT Mass (g)	309		
Est. VAT Volume (cm^3)	334		
Est. VAT Area (cm^2)	64.0		

Lean Indices

Measure	Result	Percentile YN	AM
Lean/Height^2 (kg/m^2)	15.0	32	39
Appen. Lean/Height^2 (kg/m^2)	5.47	7	19

Est. VAT = Estimated Visceral Adipose Tissue
YN = Young Normal
AM = Age Matched

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Scan Information:

Scan Date: 17 May 2019 ID: A0517190B
Scan Type: a Whole Body
Analysis: 17 May 2019 10:38 Version 13.6.0.2
Model: Horizon A (S/N 201027)
Comment:

DXA Results Summary:

Region	BMC (g)	Fat Mass (g)	Lean Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat
L Arm	102.11	1620.8	1266.4	1368.5	2989.3	54.2
R Arm	89.97	1393.5	1298.7	1388.7	2782.2	50.1
Trunk	398.27	8414.6	17259.9	17658.2	26072.7	32.3
L Leg	248.12	4333.3	4620.2	4868.3	9201.6	47.1
R Leg	242.59	4573.2	4228.4	4471.0	9044.3	50.6
Subtotal	1081.05	20335.4	28673.7	29754.7	50090.2	40.6
Head	382.90	874.0	2655.3	3038.2	3912.2	22.3
Total	**1463.95**	**21209.4**	**31329.0**	**32793.0**	**54002.4**	**39.3**

TBAR1390

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Appendix P. BIA Report

TANITA
Monitoring Your Health

Health Monitor

„INDICATE Health Risks - RATE professionally - REACT prophylactically"

Prevention Check

<Gym location First name Last name>

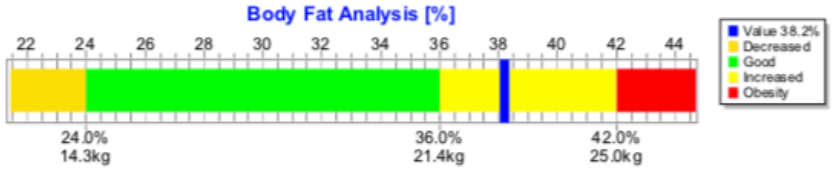
Measures on 15/03/2019 at 3:10 PM clock

(Scale type: DC-360)

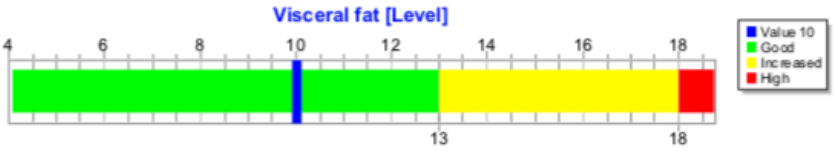
(female 75 Years) (Scale type: DC-360)

Date: 15/03/2019

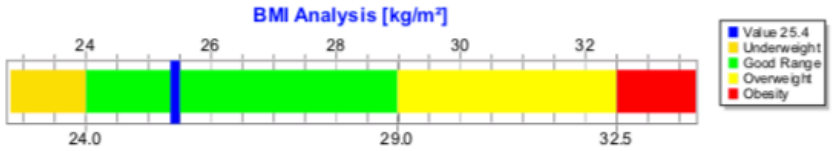
Body Fat: 38.2 %
=22.7 kg



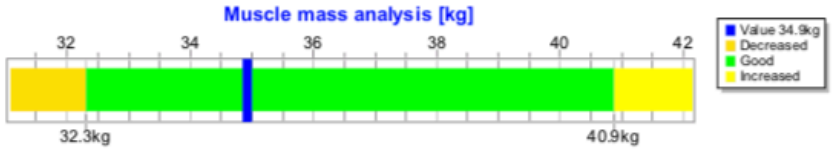
Visceral fat: 10 Level



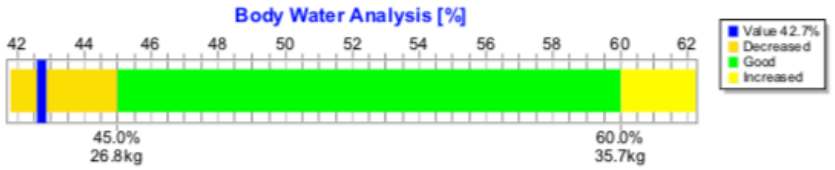
Height: 153 cm
Weight: 59.5 kg
BMI: 25.4 kg/m²



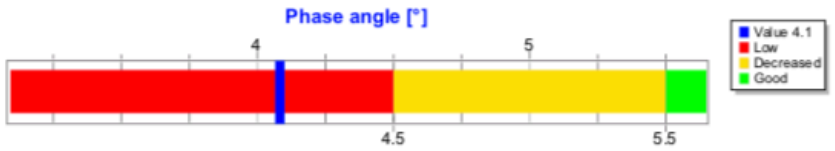
Fat Free Mass: 36.8 kg
Muscle Mass: 34.9 kg
=58.7 %
Skeletal Muscle Mass: 20.8 kg
=35.0 %
Bone Mass: 1.9 kg



Body Water: 42.7 %
=25.4 kg



Phase angle: 4.1 °
(@50kHz)



Impedance: 582 Ohm
Metabolic Age: 60 Years
Basal Metabolic Rate: 4710 kJ = 1125 kcal

Appendix Q. AES Report

The Australian Eating Survey™

Your Dietary Analysis Report

<First name Last name>

Understanding how your food intake measures up to current Australian recommendations is an important step towards improving your eating habits. This report contains the results of your Australian Eating Survey™ that was completed on **14 April 2019**

The report compares your usual dietary intake to Australian dietary recommendations, which are based on the best available scientific evidence for nutrition and health. For more information on how your Australian Eating Survey™ report is generated, please refer to website (http://www.australianeatingsurvey.com.au)

Your report contains two sections. The first section has two parts:

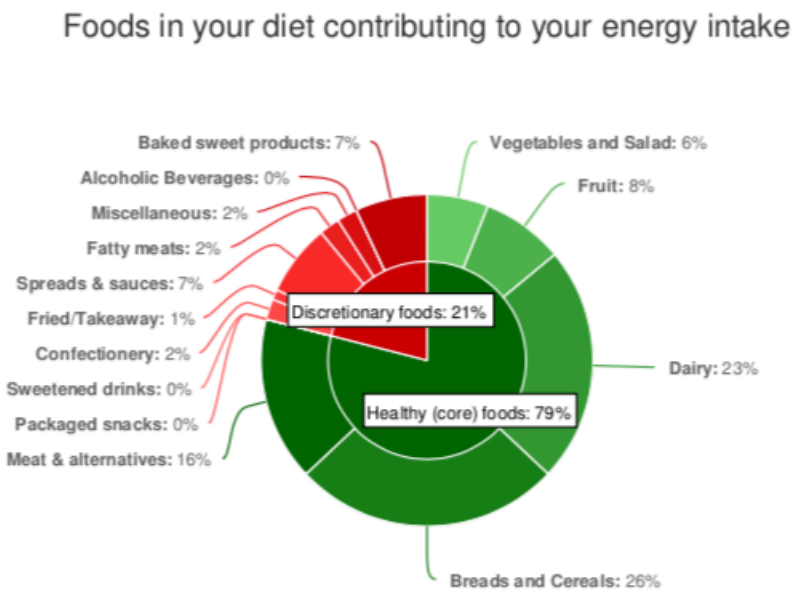
a. Your overall energy intake and the contribution of specific food groups to your average daily energy intake. It details how much of your daily energy intake (kilojoules) usually comes from healthy food groups (core foods) compared to the amount coming from less healthy foods, also called discretionary choices.
b. Your Australian Recommended Food Score (ARFS). This is a measure of how much variety within each of the healthy food groups you usually have over a week. Your ARFS is a summary score of the overall healthiness and nutritional quality of your usual eating patterns.

This section helps to identify the food groups where your intake is close to recommendations. It also shows you which areas you can try to make improvements in, either by cutting back on the amount you eat, or increasing the number of serves, or increasing the variety.

The second section gives detailed information about your nutrient intake based on the detailed analysis from your Australian Eating Survey™ responses. This includes how your macronutrient (protein, fat and carbohydrate) and micronutrient intakes (vitamins and minerals) compare with national recommended intake targets. This section also provides information on key food sources of these nutrients to help you improve your eating habits.

Your Daily Energy Intake is: 8606 kJ/day

What proportion of your food intake comes from healthy (core) foods?



This graph shows the contribution of the "healthy" and "discretionary" foods you eat as a proportion of your overall energy intake (kilojoules).

Ideal ratios:
Healthy (core) foods - aim for 85-90%
Discretionary foods - aim for a maximum of 10-15%

Healthy foods, also called "core" foods, are needed by your body every day to provide essential nutrients.

In this graph these foods have been split into five groups:

1. Vegetables
2. Fruit
3. Breads and cereals (breakfast cereals, breads, rice, noodles, pasta)
4. Milk, yogurt and cheese (including non-dairy sources)
5. Meat, chicken and fish, and meat alternatives (vegetarian choices), such as eggs, nuts, and seeds, legumes, beans.

Most Australians need to eat larger portions and have more variety of vegetables and salad, smaller portions of meat and potato, and less discretionary food choices.

Discretionary foods are energy-dense, nutrient-poor foods and drinks. The recommendation is to consume them only occasionally and in small amounts. These are foods that may be enjoyable, but your body does not need them.

Most Australians need to eat less discretionary foods.

The Australian Recommended Food Score focuses on the variety of healthy core foods you usually eat. It takes a sub-set of foods from the Australian Eating Survey™ and calculates an overall diet quality score. Your ARFS score is made up from the scores from each food group category. Higher scores indicate healthier eating patterns and a dietary intake that is of higher nutritional quality.

Category *(maximum score)*	**Your score**
Vegetables *(21 points)*	**14**
Fruit *(12 points)*	**4**
Meat, chicken and fish *(7 points)*	**2**
Vegetarian** choices (eggs, legumes, nuts) *(6 points or 12 points**)* **If you are vegetarian you can double the points for this category.	**3**
Grains *(13 points)*	**5**
Dairy *(11 points)*	**6**
Condiments *(2 points)*	**1**
Water *(1 points)*	**1**
Overall *(73 points)*	**36**

Overall ARFS (out of 73)	**Rating**
<33	Needs work
33-38	Getting there
39-46	Excellent
47+	Outstanding

Your Nutrient Intake

This section summarises your nutrient intake analysis that has been calculated from the Australian Eating Survey™*. Your results have been compared to the Nutrient Reference Values for health developed by the National Health and Medical Research Council.

Macronutrients

Protein, carbohydrate and fat are all macronutrients and contribute to your kilojoule intake (energy intake). While alcohol is not a nutrient required by the body, it does contain kilojoules and so it contributes to your energy intake.

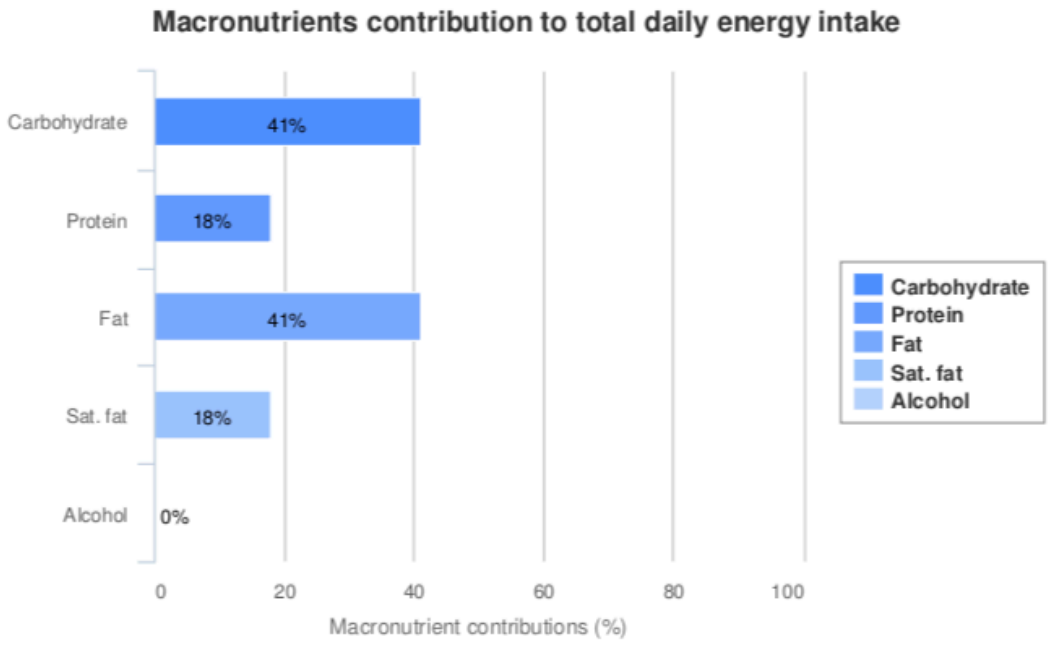
Processed and refined carbohydrates are found in discretionary foods such as savoury snack foods (e.g. potato crisps, biscuits), some drinks (e.g. soft drink, fruit juice), confectionary and desserts.

Protein: Rich sources of ***protein*** include lean meats, chicken, fish, eggs, legumes (e.g. lentils, beans, soy), nuts, dairy products.

Fat: There are four types of ***fat***: saturated, trans, monounsaturated and polyunsaturated. Major sources of saturated and trans fats include fatty cuts of meat, full fat dairy foods, butter, cream, most commercially baked products (e.g. biscuits and pastries), most deep-fried fast foods, coconut and palm oil. Food sources of monounsaturated fats include margarine spreads (canola or olive oil-based), olive, canola and peanut oils, avocado, and nuts such as peanuts, hazelnuts, cashews and

almonds. Food sources of polyunsaturated fat include oily fish (e.g. salmon, tuna, sardines), margarines and oils made from safflower, sunflower, corn or soy, and nuts such as walnuts and brazil nuts, and seeds.

How does your macronutrient intake compare to recommendations?*



Ideal intake ranges of macronutrients (as % of energy intake)*:

- Carbohydrate: 45-65%
- Protein: 15-25%
- Fat: 20-35%; Saturated fat plus Trans Fat: <10%
- Alcohol: less than 5%

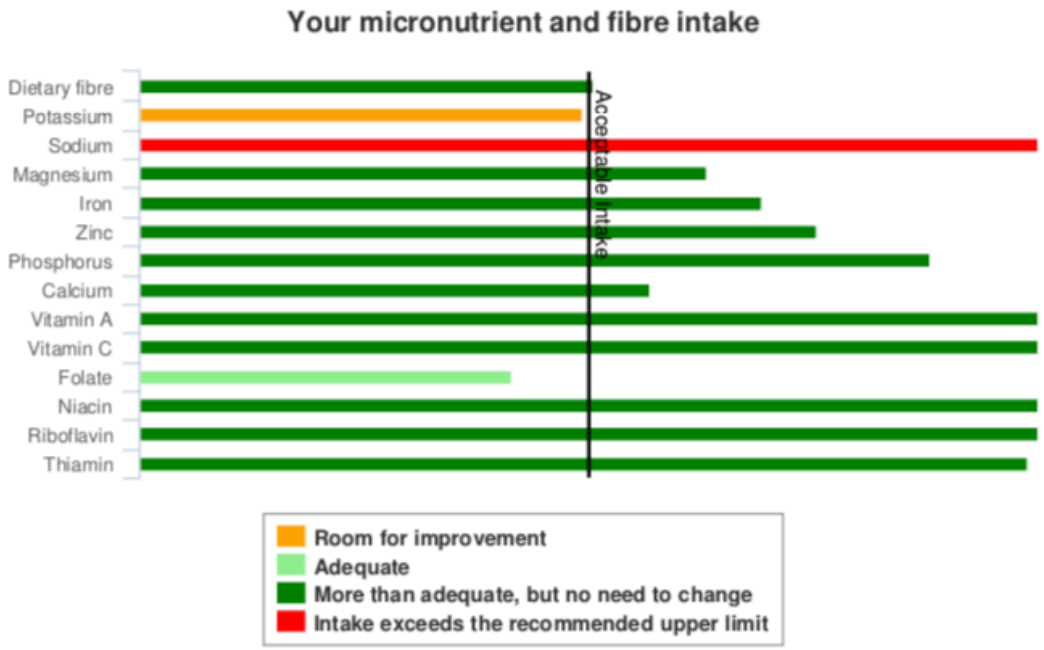
This graph shows your intake of macronutrients as proportions of your total energy intake*. A food intake that has carbohydrate, protein and fat intakes within the ideal ranges helps you to meet your requirements for general health. An increase in one macronutrient often leads to a decrease in others. If your nutrient intake is high in carbohydrate it tends to be lower in fat (and vice versa). Intakes higher in protein tend to be lower in carbohydrate and/or fat.

If you choose to consume ***alcohol***, moderation is the key. Adult recommendations are for no more than two standard drinks per day. Children, adolescents (aged less than 18 years) and women who are pregnant, planning pregnancy or breastfeeding should not drink alcohol.

Micronutrients and Fibre

Micronutrients are the vitamins and minerals that your body requires. Although the exact micronutrient requirements will vary from person to person, recommendations are made based on age, gender and life stage (i.e. pregnancy or breastfeeding). These recommendations can be used to determine whether your current food intake contains sufficient amounts of these key micronutrients.

How does your micronutrient and fibre intake measure up to recommendations?



The graph above shows your micronutrient and fibre intake* compared to the ideal intake range (i.e. Recommended Dietary Intake or Adequate Intake) for each nutrient.

For each nutrient on the graph above:

- An orange bar indicates that your usual intake for that nutrient is low and trying to eat more foods higher in this nutrient will help you reach the recommended intake.
- A light green bar indicates that your usual intake for that nutrient is in the target range but you could eat more foods that are high in this nutrient.
- A dark green bar indicates that your usual intake for that nutrient is adequate and there is no need to change.
- A red bar indicates that your usual intake for that nutrient is above the recommended limit and you should aim to cut back on foods high in this nutrient to avoid health problems. Not all nutrients have an upper limit.

Your intake of each micronutrient is shown in the table below.

Your micronutrient and fibre intake based on your usual eating patterns*:

Thiamin	**2.2** mg/day
Riboflavin	**2.7** mg/day
Niacin	**43.3** mg/day
Folate	**332.4** µg/day
Vitamin C	**144.2** mg/day
Vitamin A	**1891.5** µg/day
Calcium	**1477.7** mg/day
Phosphorus	**1762.3** mg/day
Zinc	**12.1** mg/day

Iron	**11.1** mg/day
Magnesium	**404.4** mg/day
Sodium	**2400.4** mg/day
Potassium	**2771.2** mg/day
Fibre	**25.3** g/day

Please note: Your micronutrient analysis above does not include any vitamin and/or mineral supplements that you may currently take.

Do I need to take a vitamin and/or mineral supplement?

This will depend on your situation. The nutrient analysis provided above does not account for any vitamin and/or mineral supplements that you may be taking currently nor any pre-existing medical condition or allergies. The Australian Eating Survey™ is a validated tool for measuring dietary intake, but it asks you only about foods that are most commonly eaten in Australia.

If your analysis revealed your usual food intake is inadequate in one or more micronutrients, then try to increase your intake of foods that are good sources of those nutrients. If you need more help you could discuss the results from your Australian Eating Survey™ with your doctor or an Accredited Practising Dietitian before taking a supplement. Simple changes to the foods that you usually eat will improve your nutrient intakes. Sometimes a supplement is required and your dietitian or doctor can provide you with the appropriate advice.

How do I improve my intake of vitamins, minerals and fibre?

As a guide, you may need to consume more of the foods that are good sources of the micronutrients and fibre that have been flagged in orange and light green in your graph above, and then cut back on those nutrient sources that appear in red. The table below contains general information about these nutrients, including the key food sources.

I would like further advice on how to improve my diet, what should I do?

An Accredited Practising Dietitian is best placed to provide you with individualised dietary advice based on your Australian Eating Survey™ results. Click here to find a dietitian. (https://daa.asn.au/find-an-apd/)

Nutrient	Food sources^
Thiamin (Vitamin B1)	Wholemeal cereal grains, sesame seeds, soy beans and other dried beans and peas, wheatgerm fortified breakfast cereals, bread, yeast extracts including Vegemite® and Promite®, watermelon, yeast and pork.
Riboflavin (Vitamin B2)	Milk, yoghurt, cheese, wholegrain breads and cereals, egg white, leafy green vegetables, mushrooms, Vegemite® and Promite®, meat, liver and kidney.
Niacin (Vitamin B3)	Lean meats, milk, eggs, wholegrain breads and cereals, tuna, salmon, nuts, leafy green vegetables.
Folate (folic acid)	Green leafy vegetables, legumes, seeds, liver, poultry, eggs, cereals and citrus fruits. Many cereal-based foods in Australia, such as bread and breakfast cereals, are fortified with folate.
Vitamin C	Fruit, especially citrus, pineapple, mango and pawpaw. Vegetables, especially capsicum, broccoli, Brussels sprouts, cabbage, spinach.
Vitamin A	Dark yellow, orange and dark green vegetables and fruit such as apricots, mango and rockmelon, carrots, sweet potato and pumpkin, spinach and broccoli.
Zinc	Meat, chicken, fish, oysters, legumes, nuts, wholemeal and wholegrain products.
Iron	There are two types of iron. **Haem iron** (which is more easily absorbed) - found in animal foods such as beef, chicken and fish and in liver and kidney. **Non-haem iron** - found in plant foods such as beans, nuts, lentils and leafy green vegetables. Vegetarian sources include iron-fortified breakfast cereals, flours and grains. Vitamin C and cooking boost iron absorption.
Calcium	Dairy foods, such as milk, cheese, yoghurt, canned salmon and sardines with the bones, fortified soy milks, leafy green vegetables, such as broccoli, bok choy, Chinese cabbage and spinach, brazil nuts, almonds and sesame seed paste (tahini).
Phosphorous	Lean meats, chicken, fish, milk, yogurt and cheese.
Magnesium	Tofu, soy beans, nuts, seeds, lean meat, spinach, barley, wheatgerm, brown rice, avocado, bananas, peanut butter and peas.
Sodium	Processed meats (e.g. ham, bacon, sausages), snack foods (e.g. biscuits, potato crisps), takeaway foods (e.g. pies, sausage rolls), canned foods (e.g. soups), and savoury cooking sauces (e.g. pasta and stir-fry sauces) and condiments (e.g. tomato sauce, mayonnaise). Breads and fat spreads, breakfast cereals and cheese can also be high in sodium but provide many other important nutrients.
Potassium	Most fruits and vegetables, particularly leafy greens, potatoes, tomatoes, pumpkin, legumes, bananas, oranges, dairy products, and nuts.
Fibre	Wholemeal and wholegrain breads, pastas, rices, and breakfast cereals, psyllium, bran.

^The suggestions regarding the food sources of these nutrients are general and do not take into consideration if you need to avoid certain foods due to any pre-existing medical condition, allergies, intolerances or personal preference.
If you are concerned about your nutrient intake, please consult an Accredited Practising Dietitian for advice.

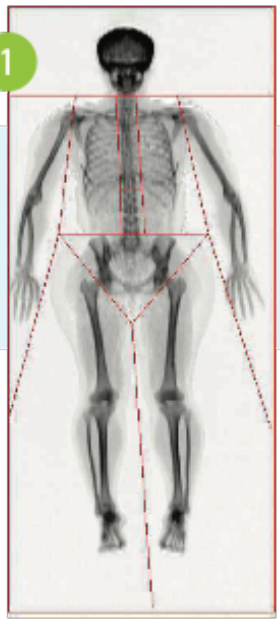
Appendix R. DEXA Fact Sheet

MeasureUp

TOTAL BONE DENSITY REPORT

TOTAL BODY BONE DENSITY SCAN

1



DID YOU KNOW?

As we age, our **total bone mass** usually decreases. Regular participation in weight-bearing activity and resistance exercise (e.g. weight training) can not only delay the start of and slow bone loss, but it may even increase bone mass in older people and postmenopausal women. Unlike other body composition assessment methods, **DEXA** is able to measure **(BMC)** and takes bone mass into account when calculating your **total body composition**.

2 **DXA Results Summary:**

Region	Area (cm^2)	BMC (cm^2)	BMD (g/cm^2)
L Arm	206.25	161.12	0.781
R Arm	209.43	163.84	0.782
L Ribs	133.93	104.91	0.783
R Ribs	121.61	86.37	0.710
T Spine	119.22	119.32	1.001
L Spine	53.65	61.78	1.152
Pelvis	189.96	245.89	1.294
L Leg	330.24	404.91	1.226
R Leg	334.61	411.05	1.228
Subtotal	1698.90	1759.18	1.035
Head	255.13	793.37	3.110
Total	**1954.04**	**2552.55**	**1.306**

EXAMPLE

TBAR1209

TOTAL BODY BONE DENSITY RESULTS BY REGION: DXA RESULTS SUMMARY

The total body bone density scan measurement can help identify persons who may be at greater risk for fracture due to decreased bone density.

Region: Represents the region of the body that is being measured for example L Arm is Left Arm. T Spine is Thoracic Spine region which refers to the upper and middle back. L Spine is the Lumbar Spine region which refers to the lower back.

Area: Represents the bone surface area of the region of your body being measured in centimetres squared (cm^2).

Bone Mineral Content (BMC): BMC represents the weight of all the bones in your body measured in grams (g). This is also known as **total bone mass**.

Bone Mineral Density (BMD): Is BMC (g) divided by the Area (cm^2) from which the measure was taken. BMD is usually measured in specific clinical regions such as the lower back (lumbar spine) and the top of the leg bone (femoral neck). These sites are clinically important, as it's where the majority of fractures occur, particularly in women, as a result of low BMD or osteoporosis.

HOW DO YOU COMPARE?

In your report, we are referring to the **BMC (g)** column.

The dry weight of the skeleton of most males weighs between 2kg and 4kg.

The dry weight of the skeleton of most females weighs between 1.5kg and 2.5kg.

The wet component, bone marrow and water, can weigh up to 2-3kg on top of the weight of your bones.

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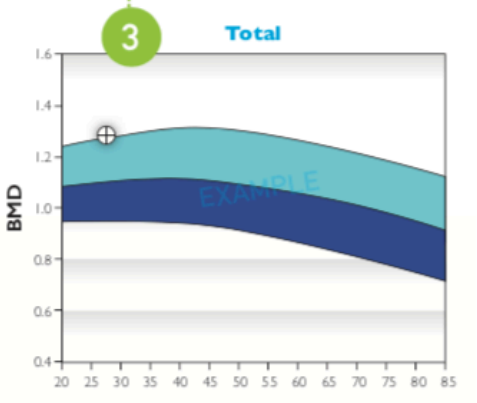
TOTAL BONE DENSITY REPORT

TOTAL BODY BONE MINERAL DENSITY (BMD) PLOT COMPARED WITH AGE

This graph plots your total BMD when compared with your age.

The circle indicates where your total BMD lies according to average adults your age. The light blue area is ideal.



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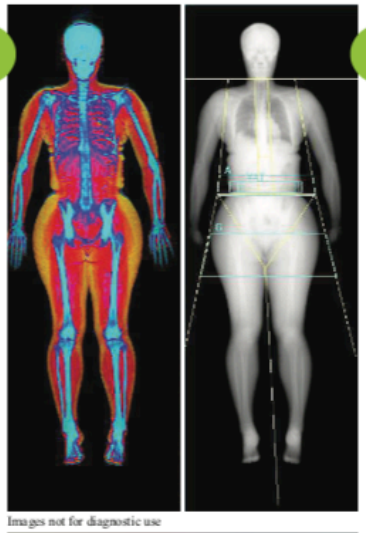
TOTAL BODY COMPOSITION REPORT

1 DIGITAL BODY COMPOSITION IMAGE

This image is a graphic representation of bone, lean mass and fat mass.

The different tissue types are shown as; blue for bone, lean tissue is red/pink and fat tissue is yellow.



2 X- RAY IMAGE WITH MARKERS PLACED FOR 8 BODY REGIONS

- Left Arm
- Right Arm
- Trunk (Torso)
- Left Leg
- Right Leg
- Head
- Android (Abdomen region)
- Gynoid (Hip/Buttock region)
- Visceral Adipose Tissue (VAT)

3 BODY COMPOSITION RESULTS TABLE

Table showing precise measurements of:

Fat mass: The amount of fat, in grams (g), in the body. Also known as **adipose tissue.**

Region	Fat Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat	% Fat percentile	
					YN	AM
L Arm	1250	2622	3872	32.3	32	29
R Arm	1164	2770	3933	29.6	24	22
Trunk	6607	24006	30613	21.6	22	19
L Leg	4016	8914	12931	31.1	15	14
R Leg	4097	9090	13186	31.1	14	13
Subtotal	17134	47402	64535	26.5	19	16
Head	914	3908	4823	19.0		
Total	**18048**	**51310**	**69358**	**26.0**	**19**	**16**
Android (A)	960	3406	4366	22.0		
Gynoid (G)	3645	8215	11860	30.7		

DID YOU KNOW?

As a consequence of childbearing and other hormone-related functions, females require about 3 times (12-14% of body mass) as much essential fat when compared with males (3% of body mass). Utilisation of this reserve may impair normal body function.

Lean Mass + Bone Mineral Content (BMC g): The amount of **fat free mass (lean mass) + bone mineral content (BMC)** in that region of your body in grams (g). **Fat free mass** refers to mass with no extractable fat namely; muscle, organs, connective tissue (tendons, ligaments etc), bone marrow & body fluids (blood & water). This number is used to determine resting metabolic rate (RMR).

Total Mass (g): Is **fat mass** plus **lean + BMC = Total mass in grams (g)**.

% Fat: The amount of fat mass as a percentage of the total mass of that region. E.g if the total mass is 50000g (50kg) and the Fat Mass is 25000g (25kg) then the % fat is 50% (25000g/50000g)

Total: The sum of Total Mass, Fat Mass & Lean Mass + BMC to give overall % body fat. Total % body fat reflects the proportion of your total body weight that is **fat mass**.

Android (A): Abdominal region

Gynoid (G): Hip/buttock region

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RECOMMENDED % BODY FAT RANGES

	Age	Low	Recommended	High	Very High
Female	20-39	5-20	21-33	34-38	>38
	40-59	5-22	23-34	35-40	>40
	60-79	5-23	24-36	37-41	>41
Male	20-39	5-7	8-20	21-25	>24
	40-59	5-10	11-21	22-27	>27
	60-79	5-12	13-25	26-30	>30

Based on Gallagher et al., American Journal of Clinical Nutrition, Vol.72, Sept. 2000

HOW DO YOU COMPARE?

In your report, we are referring to the **Fat (g)** column.

Total fat of most males should weigh between 10kg and 15kg and up to 20kg in very tall individuals.

Total fat of most females should weigh between 20kg and 25kg. You are doing very well if you fall between 15kg to 20kg. Professional female athletes normally sit between 10kg and 15kg of total fat mass.

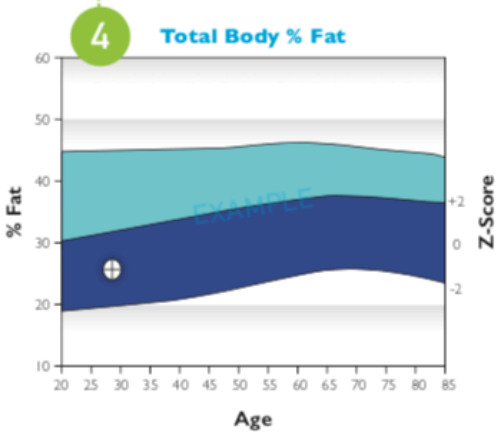
PLOT OF % FAT COMPARED TO AGE GROUP

This graph plots your total % body fat compared with your age.

The line in the middle of the 2 different coloured blues (light blue and dark blue) denotes the average % fat of people aged as per the horizontal axis. Please look at where your result is plotted. If your circle is above the middle line, your % fat is above the average % fat of people the same age and gender as you. If your circle is below the middle line, your % fat is below the average % fat of people the same age and gender as you.

Z-Score: The Z-Score on the right hand side of the graph is a statistical representation of how your % body fat compares to an **age matched reference mean**. This is another way of saying the mean (average) of adults the same age and gender as you.

The z-score bands here are +2 and -2 standard deviations.



Source: NHANES Classic White Female.

MeasureUp

TOTAL BODY COMPOSITION REPORT

5

BMI INDICATOR

The Body Mass Index is unfortunately the current standard measure for clinical obesity. The problem with BMI is that it is a measure of excess weight, not excess fat and it is not gender specific.

BMI is a two factor equation which only accounts for height and weight. It does not account for your muscle mass or your body composition in the equation.

MeasureUp does not calculate BMI as it is a flawed method of clinical assessment. A much more robust index is the FMI or Fat Mass/Height^2 (kg/m^2) which takes into account your fat mass relative to your height.

6

ADIPOSE INDICES

This table represents measurements of the adipose (fat tissue) in your body. Fat mass includes your essential fat as well as your storage fat.

Region	Result	% Fat percentile	
		YN	AM
Total % Body Fat	**26.0**	**19**	**16**
Fat Mass / Height^2 (kg/m^2)	6.79	36	33
Android / Gynoid Ratio	0.72		
% Fat Trunk / % Fat Legs	0.69	38	34
Trunk/Limb Fat Mass Ratio	0.63	26	22
Est. VAT Mass (g)	237		
Est. VAT Volume (cm^3)	256		
Est. VAT Area (cm^2)	**49.1**		

EXAMPLE

Essential fat: is the fat required for normal functioning and is stored in the marrow of bones as well as in the heart, lungs, liver, spleen, kidneys, intestines, muscles and the central nervous system.

Storage fat: is excess fat that consists of two components;

1. Subcutaneous fat: is found predominantly directly beneath the surface of the skin.

2. Visceral adipose tissue (VAT): is found in the intra-abdominal cavity (greater omentum) area below the abdominal muscles. Visceral fat (VAT) is stored around major vital organs such as the liver, kidney and pancreas. Visceral Fat is very mobile and is strongly correlated with metabolic diseases such as insulin resistance, type 2 diabetes and cardiovascular disease. An excess of body fat (storage fat) is undesirable for good health and fitness.

Total Body % Fat: Total % body fat reflects the proportion of your body weight that is fat mass.

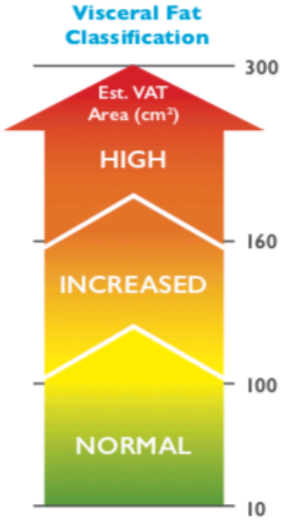
Fat Mass/Height^2 (kg/m^2): Known as the Fat Mass index, indicates how much fat mass you have relative to your height. This is the best measure of excess fat. Ideally males should be below 4.0kg/m^2 and below 5.5kg/m^2 for females.[1]

Android/Gynoid Ratio: The Android / Gynoid ratio (A/G) compares your Android fat (Abdomen region) to your Gynoid fat (hip region) to assess your body fat distribution. Anything greater than 1.0 indicates your Android (abdomen) region has greater fat distribution than your Gynoid (Hip region) and vice versa. We also find these two regions very useful in examining fat loss from these specific regions over time. Did your fat loss come from your abdomen or your hips?

Est VAT (cm^2): Estimated amount of visceral fat. The research literature suggests that if your Est. Vat Area (cm^2) is greater than 100, you may have an increased risk of metabolic diseases such as insulin resistance, type 2 diabetes and cardiovascular disease.

% Fat Percentile YN: If your YN percentile is 40, it means your %fat is greater than 40% of young normal (YN) adults. The lower the number, the better.

% Fat Percentile AM: If your YN percentile is 35, it means your %fat is greater than 35% of age matched (AM) adults (adults the same age as you). The lower the number, the better.



1. Schutz et al. Int J Obes. 26, 953-960 2002

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LEAN INDICES

7

This table represents measurements of the fat free (lean) mass in your body. The most important measurement in this table is;

Appen. Lean/Height²(kg/m²): This is known as the Skeletal muscle mass index (SMI). If your SMI is below 7.26kg/m² for males and 5.5kg/m² for females you are defined as having Sarcopenia (low muscle mass).[2]

Measure	Result	Percentile	
		YN	AM
Lean/Height² (kg/m²)	18.4	83	81
Appen. Lean/Height² (kg/m²)	8.38	88	87

EXAMPLE

Est. VAT = Estimated Visceral Adipose Tissue
YN = Young Normal
AM = Age Matched

Lean Indices Percentile YN: If your YN percentile is 40, it means your lean mass is higher than 40% of young normal (YN) adults. The higher the number, the better.

Lean Indices Percentile AM: If your YN percentile is 35, it means your lean mass is higher than 35% of age matched (AM) adults (adults the same age as you). The higher the number, the better.

HOW DO YOU COMPARE?

In your report, we are referring to the **Lean (g)** column.

Total lean mass of most males should weigh over 60kg and over 55kg in shorter individuals.

Total lean mass of most females should weigh 40kg and over 35kg in shorter individuals.

DXA RESULTS SUMMARY

8

This table shows your BMC, Fat Mass, Lean Mass, Lean + BMC, Total Mass and % Fat for each region. This table differs from the Body Composition Results Table 3 by separating out Lean Mass from BMC.

From this table you can determine muscle symmetry between L & R Arm as well as L & R Leg by viewing the Lean Mass column.

Region	BMC (g)	Fat Mass (g)	Lean Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat
L Arm	161.12	1249.8	2461.3	2622.4	3872.2	32.3
R Arm	163.84	1163.7	2605.8	2769.7	3933.3	29.6
Trunk	618.27	6607.1	23387.6	24005.9	30613.0	21.6
L Leg	404.91	4016.5	8509.2	8914.1	12930.5	31.1
R Leg	411.05	4096.6	8678.7	9089.8	13186.4	31.1
Subtotal	1759.18	17133.7	45642.6	47401.8	64535.4	26.5
Head	793.37	914.1	3115.1	3908.5	4822.6	19.0
Total	**2552.55**	**18047.8**	**48757.7**	**51310.2**	**69358.0**	**26.0**

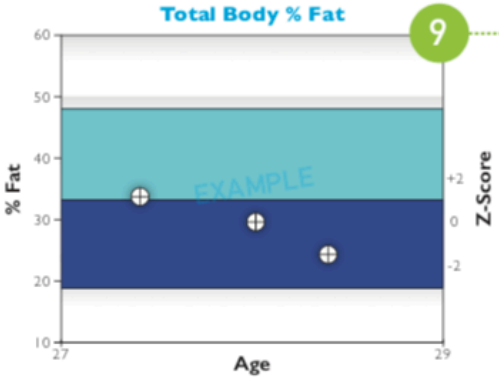
EXAMPLE

The larger the difference, the larger the muscle imbalance between your left and right arm or leg. Your dominant arm will often have higher Lean Mass than your non-dominant arm (200-300g). The same applies to your legs with a difference of less than 10% being normal.

If you have had a previous DEXA scan with MeasureUp, you can also use this table to see exact regional changes in your fat mass and lean mass over the course of your scan history. By comparing each region of your body to previous scans, you are able to identify exactly where you have lost fat, gained muscle or vice versa.

2. Cruz-Jentoft et al. Age Ageing. 39, 412-423 2010

Total Body % Fat



Source: NHANES Classic White Female.

9

TRACKING YOUR % BODY FAT, FAT MASS & LEAN MASS VALUES OVER TIME

If you are a repeat client and track your changes using DEXA, we are able to provide you with rate of change graphs and reports over the course of your scan history. These graphs and tables provide you with an easy reference point for changes that have occurred in your body composition over time.

9.1 Total Body % Fat Results Over Time

Scan Date	Age	% Fat	Lean Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat
27.03.2017	28	26.0	19	16	-7.9	-3.0
17.11.2016	28	29.0	32	29	-4.9	-4.9
10.03.2016	27	33.9	57	54		

EXAMPLE

9.2 Total Fat Mass Results Over Time

			Change/Month vs		Change vs	
Scan Date	Age	Fat Mass (g)	Baseline	Previous	Baseline	Previous
27.03.2017	28	18048	-751	-673	-9425	-2874
17.11.2016	28	20921	-791	-791	-6552	-6552
10.03.2016	27	27473				

EXAMPLE

9.3 Total Lean Mass Results Over Time

			Change/Month vs		Change vs	
Scan Date	Age	Fat Mass (g)	Baseline	Previous	Baseline	Previous
27.03.2017	28	48758	-185	42	-2324	178
17.11.2016	28	48580	-302	-302	-2501	-2501
10.03.2016	27	51081				

EXAMPLE

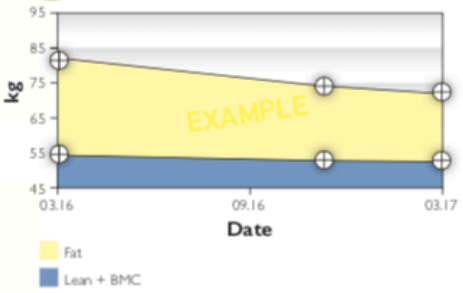
9.4 Total Mass Results Over Time

			Change/Month vs		Change vs	
Scan Date	Age	Fat Mass (g)	Baseline	Previous	Baseline	Previous
27.03.2017	28	69358	-926	-627	-11616	-2677
17.11.2016	28	72035	-1080	-1080	-8939	-8939
10.03.2016	27	80974				

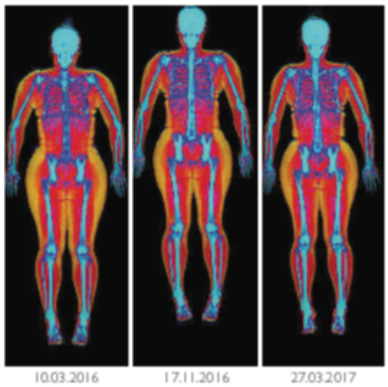
EXAMPLE

YN = Young Normal
AM = Age Matched

9.5 Compartmental Trending



9.6 Visual colour comparison over time of changes in your body composition



GLOSSARY

Body composition	The ratio of lean body mass (structural and functional elements in cells, body water, muscle, bone, heart, liver, kidneys, etc.) to body fat (essential and storage) mass.
Dual energy x-ray absorptiometry (DEXA)	The gold standard test for measuring bone density and body composition. It can accurately and precisely monitor changes in muscle, bone and fat in those who are undergoing clinical management of a condition, weight loss treatments and health and fitness programs. It is painless and non-invasive, requiring no special preparations. For this exam, you lie on a padded table while the x-ray scanning machine moves over your entire body. The exam takes about 6 minutes to complete, and the radiation dosage from the x-ray is less than 10% of that used for a chest x-ray or less than the exposure from an airline flight from Sydney to Brisbane.
Bone mineral content (BMC)	The total amount of bone mass in the skeleton that is expressed in grams (g).
Bone mineral density (BMD)	BMD is measured in grams per square centimetre (g/cm2) using dual energy x-ray absorptiometry or BMC divided by Area.
Fat mass – Fat (g)	The amount of fat, in grams (g), in the body. Fat contains nine calories per gram; it has the most calories of the macronutrients.
Lean mass – Lean (g)	Everything in the body except fat, including organs, skin and all body tissue including muscle tissue. Approximately 50-60% of lean body mass is water. The same as FFM.
Fat free mass (FFM) – Lean + BMC (g)	Another term for lean body mass, FFM refers to muscle, bones, organs, and connective tissue. The three compartments of the body are fat free mass, fat mass, and water.
Osteopenia	A condition in which there is a decrease in bone mineral density but not necessarily an increase in the risk or incidence of fracture.
Osteoporosis	A condition in which there is a decrease in bone mineral content and bone mineral density and an increased risk and/or incidence of fracture.
Visceral adipose tissue (VAT)	VAT area is a specific assessment of your abdominal region (Central Adipose Tissue). The research literature suggests that if your Est. VAT Area (cm^2) measurement is over 100g/cm^2 you have an increased risk of cardiovascular disease and/or type 2 diabetes.
T-score	A statistical measure used to determine the SD about a young adult mean. In the BD area you are compared to a group of young adult females aged 20 - 29 years.

Appendix S. Refereed Abstract Publications

Table S.1:
Refereed Abstract Publications

Title	Authors	Refereed abstract publication	Journal
Associations of sarcopenia and its components with self-reported health-related quality of life, physical activity, and nutrition in older adults performing exercise training	1. Ewelina Akehurst: Research student, Victoria University 2. David Scott: Fellow in the School of Clinical Sciences, Monash University 3. Juan Peña Rodriguez: Honours student, the National University of Colombia, Colombia 4. Carol Alonso Gonzalez, Honours student, the National University of Colombia, Colombia 5. Jasmaine Murphy, Honours student, Victoria University 6. Sandor Dorgo: Professor, the University of Texas at El Paso, TX 7. Alan Hayes: Professor, Victoria University	Abstract accepted September 6, 2019 for the Australian and New Zealand Society for Sarcopenia and Frailty Research (ANZSSFR) 2019 Annual Meeting to be held on 22–23 November 2019, Hilton Sydney, NSW	*Australasian Journal on Ageing*
Comparison of exercise program modalities on their impact on fitness and body composition scores in older adults	1. Sandor Dorgo: Associate Professor, the University of Texas at El Paso, TX 2. Ewelina Akehurst: Research student, Victoria University 3. David Scott: Fellow in the School of Clinical Sciences, Monash University 4. Alan Hayes: Professor, Victoria University	Poster presentation at the National Strength and Conditioning Association's (NSCA) 41st Annual Meeting, July 12-14, 2018, Indianapolis, IN, US	*Journal of Strength and Conditioning Research*
Comparison of Strength and Power Training on Muscular Fitness and Body Composition in Older Adults	1. Alan Hayes: Professor, Victoria University 2. Ewelina Akehurst: Research student, Victoria University 3. David Scott: Fellow in the School of Clinical Sciences, Monash University 4. Sandor Dorgo: Associate Professor, the University of Texas at El Paso, TX	Poster presentation at the Australian and New Zealand Society for Sarcopenia and Frailty Research 3rd Annual Meeting, November 23-25, 2018, Dunedin, NZ	*Australian Journal on Ageing*