Active Ageing: A Novel Dynamic Exercise Initiative for Older People to Improve Health and Well-Being

Myrla Patricia Reis Sales

Licentiate in Phys Ed / Exercise Science

MAppSc (Clinical Exercise Practice)

Accredited Exercise Physiologist

Submitted in fulfilment of the requirements
for the degree of Doctor of Philosophy

Victoria University
2017

Active Ageing: A Novel Dynamic Exercise Initiative for Older People to Improve Health and Well-Being

Abstract

Background

Falls and related injuries are the leading cause of mortality and morbidity in people aged 65 years and older. Despite all the many health benefits already reported from regular exercise participation including reduction of falls, this population group is still reported to be inadequately physically active. Therefore, it is critical to develop and validate new options that can enhance exercise uptake, sustain participation of this group and reduce their risk of having falls.

Senior exercise parks, which consist of outdoor exercise equipment with multiple stations, were designed to improve muscular strength and physical function in older adults through fun, challenging but safe activities. Hence, senior exercise parks may potentially be an option to reduce falls risk and improve older adults' quality of life. As such, the overall aim of this thesis was to investigate the feasibility and effectiveness of an 18-week exercise program using the senior exercise park in reducing the risk of falls (i.e., improve muscular strength, balance and physical function) among older adults. Specifically, this thesis examined the effect of an 18-week exercise intervention on physical measures, and health related measures and which of these measures can be sustained for a short period of time (8-weeks) post-intervention (carry-over effects). Moreover, acceptability, barriers, enablers, perceived benefits and outcomes as well as recruitment rate, adherence, safety and adverse effects were also assessed to determine feasibility. This thesis provided a further insight regarding a broader range of older adults' global and physical self-perception changes as well as social activity participation change after participating in the outdoor senior exercise park intervention. It also investigated how changes in self-esteem and self-perceptions would change social activity participation levels (e.g., enhancement) after completion of the 18-week senior exercise park intervention.

Methods

This thesis was part of a randomized controlled trial with pre and post intervention design (outcome assessments at baseline and at 18 and 26 weeks after participation commencement) comparing an exercise park intervention group (EPIG) with a control group. Participants from the EPIG underwent an 18-week exercise intervention with no cost to the participants. Participants in the control group were advised to continue with their usual daily activities and met the research team every two weeks to take part in some social activities (nine meetings of two-hour duration over 18 weeks of participation). Quantitative and qualitative data were used to draw the conclusions about the abovementioned aims and outcomes.

Results

Sixty-six community-dwelling older adults (M Age = 71.2 ± 6.7 years; 47 females, 19 males) completed physical tests measuring their muscle strength and physical function, and some quality of life, physical and psychosocial questionnaires and were randomised to two groups (Exercise Park Intervention Group and Control Group). Intervention group showed significant improvement on measures of muscle strength ($p < 0.01$, 95%CI -29.14 to -5.86), balance ($p = 0.02$, 95%CI -8.35 to -.549) and physical function (two-minute walk ($p = 0.02$, 95%CI -19.13 to -.859) and timed sit to stand ($p = 0.03$, 95%CI -2.26 to -.143)) after 18 weeks of exercise intervention participation which was maintained for a short period of time (8 weeks) following the completion of the intervention period. Twenty-seven participants were selected for face-to-face interviews to explore in-depth participants' experiences with the project. Thematic analysis of interview data revealed that the exercise intervention proposed was very enjoyable and with varied perceived benefits and outcomes.

Participants of the intervention group significantly improved their physical self-worth after 18 weeks of exercise participation ($p = 0.02$). No significant changes were reported in their levels of social activity after participation. This thesis was able to show a strong correlation between improvements in perceptions of coordination and strength levels and change in social activity levels among older adults.

Conclusions

The findings from the present thesis suggest that the senior exercise park program is a feasible, well-accepted and effective exercise initiative for older adults to reduce their risk factor for falls. Such exercise program has been shown to be safe and therefore might enhance exercise uptake, attendance and sustain participation in exercise programs for older adults in the community.

Statement of Originality

I, Myrla Patricia Reis Sales, declare that the PhD thesis titled Active Ageing: A Novel Dynamic Exercise Initiative for Older People to Improve Health and Well-Being is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

[redacted]

Myrla Sales 21 Apr 2017

Statement of Authority of Access

I, Myrla Patricia Reis Sales, author of this thesis titled Active ageing: A novel dynamic exercise initiative for older people to improve health and well-being, submitted for the degree of Doctor of Philosophy, agree that this thesis may be made available for loan and limited copying and communication in accordance with the Copyright Act 1968.

Acknowledgements

Firstly, I would like to kindly thank all the sixty-six participants of this project without whom there would be no thesis. Their generosity in sharing their time with me has been deeply appreciated. All of you have left a bit of your beautiful story with me and made this new story possible. I cannot thank you enough.

I also would like to thank my wonderfully supportive supervisory team for their belief in me even when I started doubting myself if I could get to finish this PhD. Thank you immensely for keeping pushing me until you have got the best out of me and for everything you did for me during all these four years.

I deeply thank my research assistant and friend Ms. Caitlin Dodd who actively participated in this project during the data collection, testing of participants and data entry. Thank you, girl, your help was ineffable.

I cannot forget to thank my students who had placement with me during the data collection of this project. Their willingness to help and learn made the senior exercise park intervention special and memorable for all of us involved.

Furthermore, I would also like to express my sincere gratitude to Mrs. Tuire Karaharju-Huisman for having handpicked me to make this project happen. I truly appreciate your trust in me, my friend.

I need to intensely thank my parents out there in Brazil who raised me to be the person I am today and my lovely brother who has always been an inspiration in everything I do.

And, finally, but not least, I need to forever thank my lovely husband Wilson whose support has helped to make this all possible and instilled in me a sense of pride to constantly persevere despite numerous challenges I have been facing throughout all these years. Thank you infinitely for being with me in this journey.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BOOMER: Balance Outcome Measure for Elder Rehabilitation

CG: Control group

EPIG: Exercise Park Intervention Group

IPEQ: The Incidental and Planned Exercise Questionnaire (Interchangeably used in this thesis as IPAQ)

PSDQ: Physical Self-Description Questionnaire

RCT: Randomised Controlled Trial

SF-12v2™ or SF-12: The Short Form (12) Health Survey

SF12-PCS: Physical and Component Score of the Short Form (12) Health Survey (SF-12)

SF12-MCS: Mental Component Score of the Short Form (12) Health Survey (SF-12)

Short-FES-I: Short Form - The Falls Efficacy Scale International

List of Peer Reviewed Publications

This thesis contains four manuscripts that have been accepted for publication (Chapter 3, 4, 5 and Appendix 6, respectively).

Sales MP, et al., *A novel dynamic exercise initiative for older people to improve health and well-being: study protocol for a randomised controlled trial.* BMC Geriatrics. 2015. 15(1):68.

Sales M, et al., *A Novel Exercise Initiative for Seniors to Improve Balance and Physical Function.* Journal of Aging Health. 2016. DOI: 10.1177/0898264316662359

Sales M, et al., *Relationships between Self Perceptions and Physical Activity Behaviour, Fear of Falling, and Physical Function among Older Adults.* European Review of Aging and Physical Activity. 2017. 14(1). DOI: 10.1186/s11556-017-0185-3

Sales M, et al., *Older Adults' Perceptions to a Novel Outdoor Exercise Initiative: A Qualitative Analysis.* The International Journal of Aging and Society. 2018 (Press).

List of Conference Presentations

Sales, M., Polman, R., Hill, K. D., Levinger, P. (2017). Active Ageing: A novel exercise initiative for older adults. The 2nd Victorian Allied Health Research Conference – Melbourne, Australia - Oral Presentation. 31st March 2017.

Sales, M., Polman, R., Hill, K. D., Levinger, P. (2017). Exploring older adults' perceptions, motivations, barriers and benefits to a novel outdoor exercise initiative. The 2nd Victorian Allied Health Research Conference – Melbourne, Australia - Poster Presentation. 31st March 2017.

Sales, M., Polman, R., Hill, K. D., Levinger, P. (2016). A Novel Exercise Initiative for Older Adults to Reduce Falls Risk and Improve Physical Function: a Randomized Controlled Trial. The 7th Biennial Australian and New Zealand Falls Prevention Conference – Melbourne, Australia - Oral Presentation. 27th - 29th November 2016.

Sales, M., Polman, R., Hill, K. D., Levinger, P. (2016). Active Ageing: A Novel Dynamic Exercise Initiative for Older People to Improve Health and Well-Being. World Congress in Active Ageing – Melbourne, Australia - Oral Presentation. 28th June – 1st July 2016.

Sales, M., Polman, R., Hill, K. D., Levinger, P. (2016). Overall and seasonal weather based adherence to an exercise intervention among community dwelling older adults using an outdoor senior exercise park. Exercise & Sports Science Australia (ESSA) – Research to Practice 2016 – Melbourne, Australia - Oral Presentation. 14th -16th April 2016.

Sales, M., Levinger, P, Polman, R. (2015). Fear of falling, physical activity levels and objective measures of strength and physical function, and physical and global self-perceptions among community dwelling older adults. The 14th National Conference of Emerging Researchers in Ageing. National Ageing Research Institute – Melbourne, Australia – Oral Presentation. 7th – 8th December 2015.

Levinger, P., **Reis Sales, M.**, Karaharju-Huisman, T., Begg, R., Hill, K.D., Polman, R. (2014). Community exercise park program to reduce falls risk in elderly: feasibility study. The 6th Australian and New Zealand Falls Prevention Conference - Sydney, Australia – Oral Presentation. 16th – 18th November 2014.

Project Awards

2017:

2nd Victorian Allied Health Research Conference - Best Allied Health Award: Best Oral Presentation and Most Innovative Community Project

2016:

Doutta Galla Research Support Award – Innovative Project for the Ageing Community

List of Appendices

Chapter 1 – Introduction

Falls continue to be a common problem affecting older people, with 30-40% of those aged 65 and over, and half of those aged over 85, falling each year [1-3]. In 2016, Australia had 15.3% of its population aged 65 years and over [4]. Among them, approximately 10% have multiple falls every year [5] and 20% of those who fall experience injuries and require medical attention [2]. Fall rates and the risk of having multiple falls also significantly increase with age [3]. In 2011-12, 88,386 falls-related hospitalisations have been registered in Australia for people aged over 65 years, with the most common injury being hip or other lower limb fracture and this number is still on the rise [6].

Most falls have been associated with one or more identifiable risk factors [7] and the risk of falling is directly associated with the number of risk factors involved [8]. Physiological factors including lower extremity muscle weakness, gait and balance impairments, and functional impairments have been highly associated with the risk of falls and are most often targeted by preventive exercise interventions [8]. Targeting these modifiable risk factors in exercise programmes seems to be an effective way to reduce the risk of falls [2, 9].

Numerous exercise programmes available in the literature have been shown to be effective in reducing the risk of falling and the rate of falls among older adults [9] by improving their muscle strength, flexibility, balance, coordination, proprioception, reaction time and gait [10]. Even those who are very old and frail seem to benefit from these exercise programmes [10]. Additionally, exercise programmes that challenge balance and involved more than 3 hours/week of exercise are the ones with larger effects (incident rate ratio 0.61, 95% CI 0.53 to 0.72, $p<0.001$, 76% of between-trial heterogeneity explained)) [9].

However, even with many varied programmes being available for older adults to improve their muscle strength, balance, physical functional and their quality of life, and, consequently, reduce their likelihood of having a fall, older adults' participation rate is still low [11]. It is estimated that half of the individuals who begin an exercise program commonly drop out within the first 6 months of participation [12]. Thus, there is a need to improve the long-term participation in physical activity and exercise, which are not common habits for most older individuals [13].

Senior exercise parks, which consist of outdoor exercise equipment with multiple stations, were designed and originally introduced in Europe in 2008 to improve muscular strength and physical function in older adults through fun, challenging but safe activities. These senior exercise parks aim to inspire older people to be more playful and to make them exercise in a more relaxed atmosphere. They also aim to help senior citizens to have a more independent control over their lives. Furthermore, these senior exercise parks can offer children and grandparents an opportunity to play together. It is believed that this initiative could lead to a more active and healthier lifestyle among older adults [14]. Hence, senior exercise parks may potentially be an option to improve older adults' participation in physical activity as well as improve their quality of life and to reduce the growing public health problem of falls among older adults.

Preliminary results of an internal report produced by The Netherlands Organization (TNO) in 2008 regarding the use of the senior exercise park suggest the exercise parks may be safe and useful to older people, had high attendance rates, reduced fear of falling and improved muscle strength and balance among small number of participants [14]. However, further research is needed with larger sample size and a longer intervention period using a well-established scientific methodology to determine the feasibility and effectiveness of the exercise park program on physical, psychological, psychosocial and other health related outcomes among older adults. Therefore, the overall aim of this thesis was to investigate the feasibility and effectiveness of an 18-week exercise program using the senior exercise park in reducing the risk of falls (i.e., improve muscular strength, balance and physical function) among older adults. Specifically, the thesis examined the effect of an 18-week exercise intervention on physical measures, and health related measures. Moreover, acceptability, barriers, enablers, perceived benefits and outcomes as well as recruitment rate, adherence, safety and adverse effects were also assessed to determine feasibility.

This thesis also aimed to explore which physical measures, and health related measures can be sustained for a short period of time (8-weeks) post-intervention (carry-over effects). Finally, it provided further insight regarding a broader range of older adults' global and physical self-perceptions changes as well as social activity participation change after participating in the outdoor senior exercise park intervention.

1.1 Research Questions

This project in particular addressed the following research questions:

(1) What is the feasibility of an 18-week exercise intervention using the senior exercise park determined by the number of participants recruited and retained over the recruitment period, overall adherence to exercise sessions and seasonal adherence (i.e., weather- and season- based attendance), safety, adverse effects?

(2) What are the acceptability, barriers, enablers, perceived benefits and outcomes in exercising using the novel senior exercise park program?

(3) What is the effectiveness of an 18-week senior exercise park intervention on muscle strength, balance and physical function fear of falling and quality of life?

(4) What are the physical (e.g., muscle strength, balance and physical function) and health related (e.g., fear of falling and quality of life) benefits which were

sustained eight weeks after completion of the senior exercise park program as well as the changes in physical activity levels of the participants of the study?

(5) What are the effects of the 18-week senior exercise park intervention on global and physical self-esteem and self-perceptions and social activity participation after completion of the senior exercise park program?

(6) How changes in self-esteem and self-perceptions would change social activity participation levels (e.g., enhancement) after completion of the 18-week senior exercise park intervention?

1.2 Hypotheses

The following research hypotheses were formulated:

(1) It was hypothesized that the 18-week senior exercise park intervention would be feasible and safe, resulting in a satisfactory number of participants recruited and retained over the trial period (i.e., greater than 70%) with high adherence to exercise sessions.

(2) It was hypothesized that weather would play a role on the seasonal adherence with fluctuations throughout seasons.

(3) As part of feasibility, it was hypothesized that the senior exercise park project would be a well-accepted and enjoyable exercise initiative and that most participants of this research project would show willingness to continue using this exercise option after intervention completion.

(4) Participation in the 18-week senior exercise park intervention would promote improvement in physical measures such as muscle strength, balance and physical function as well as improve health-related outcomes such as quality of life and fear of falling among participants.

(5) After 8 weeks following the completion of the senior exercise park intervention, it was hypothesized that participants' physical measures evaluated in the first study (e.g., muscle strength, balance and physical function) and health related measures (e.g., fear of falling and quality of life) would be sustained.

(6) It was hypothesized that physical activity levels/behaviour would improve 8-week post intervention participation.

(7) It was hypothesized that participants would improve their physical self-perceptions and social activity participation levels after participation in the 18-week senior exercise park intervention.

(8) It was hypothesized that older adults with greater global and physical self-perceptions would engage in more social activities over time.

1.3 Outline of Thesis

This thesis includes nine chapters, five appendices, and incorporates four publications in chapters 3, 4, 5 (research aims 1, 2 and 3) and Appendix 6. This thesis encompasses a thorough review of the current literature (Chapter 2) and a general discussion of the overall thesis's findings in Chapter 8. Chapter 8 also draws the final conclusions, the limitations of the work, recommendations for implementation of the senior exercise park in the real world and future research directions.

Chapter 6 discusses the changes in global and physical self-concepts and the levels of social activity among participants following the intervention, and the changes in social activity participation in function of changes in the global and physical self-perceptions (research aims 5 and 6). Finally, Chapter 7 analyses the potential physical, physiological and health related outcomes carry over effects 8-weeks post-intervention (research aim 4).

The publications included in this thesis and their respective chapters are as follows:

Chapter 3 – "A novel dynamic exercise initiative for older people to improve health and well-being: study protocol for a randomised controlled trial" – BMC Geriatrics, 2015, 15(1), 68. This is the research protocol of the project which presents the general methods used to measure the feasibility and effectiveness of the senior exercise park program.

Chapter 4 – "A Novel Exercise Initiative for Seniors to Improve Balance and Physical Function" – Journal of Aging and Health in 2016 (doi: 10.1177/0898264316662359). This chapter reports the quantitative outcomes for feasibility and effectiveness of the 18-week senior exercise park intervention program.

Chapter 5 – "Older Adults' Perceptions to a Novel Outdoor Exercise Initiative: A Qualitative Analysis" accepted for publication in The International Journal of Aging and Society. This chapter presents the qualitative outcomes related to the feasibility (i.e., acceptability, barriers, enablers, perceived benefits and outcomes) of the 18-week senior exercise park intervention program.

Appendix 6 – "Relationships Between Fear of Falling, Physical Activity Levels, Strength and Physical Function, and Self-Perceptions Among Older Adults", published in the European Review of Aging and Physical Activity Journal (DOI: 10.1186/s11556-017-0185-3). This fourth publication was added as an Appendix 6 not to interfere with the flow of the main research questions of this thesis. The research questions discussed in this publication are not directly related to this thesis, however, its findings and discussion points (e.g., one's attitudes, actions and behaviours are guided by their beliefs and perceptions) help to elucidate some of the points discussed in Chapter 6.

Chapter 2 – Literature Review

2.1 Aging Population in Australia

Between 1996 and 2016, the proportion of the population aged 65 years and over in Australia increased from 12.0% to 15.3% [4]. This group is estimated to increase more rapidly over the next decade, as more baby boomers (those born between the years 1946 and 1964) will turn 65 [4]. Currently, only five cohorts of these baby boomers have reached 65 and there are 13 remaining which means that this population group will grow significantly over the next two decades. From June of 2015 to June of 2016, the number of people aged 65 years and over in Australia increased by 116,000 people, representing a 3.3% increase [4]. In the last twenty years, the number of persons aged 85 years and over increased by 141.2%, compared with a total population growth of 32.4% over the same period. The number of people aged 85 years and over increased by 15,100 people (3.2%) from 2015 to 2016. There were almost twice as many females (305,000) as males (179,700) in this age group which reflects the higher life expectancy for females [4]. Therefore, with this growing number of older adults in the community, it is expected that the costs associated with ageing (e.g., medications and hospitalizations) and the burden in public health will tend to increase exponentially [15]. In particular, adequate intervention programs are required for one of the most significant problem in this population group: Falls [16].

2.2 Falls Problem in Older Age

Injurious falls are a leading cause of death and disability among older adults [17]. They are a cause of substantial rates of mortality and morbidity as well as major contributors to immobility and premature nursing home placement [18].

Falls are more commonly defined as inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or any other objects [19]. Falls and the reduction of associated risk factors associated with falls are key public health priorities. In fact, one out of three older people fall each year, but less than half tell their doctor [20]. About one in 40 of people aged 65 years and over will be hospitalised and of those admitted to hospital after a fall, only about half will be alive a year later [18]. Considering older individuals who are over 70 years of age, the prevalence of a fall event is 32-42% [19] and reaches over 50% for those aged 80 and over [21]. The incidence rate of falls among older adults living in a community varies from 517 to 683 per 1,000 person-years [22].

Falls are significantly associated with reduction in quality of life of older adults as well as functional decline [23]. Over 30% of older adults who experience a fall have injuries which will require some medical treatment [5]. In 2011–12, 96,385 people aged 65 and over were hospitalised for a fall-related injury, corresponding to three and a half times as many cases as the rate among people aged 45–64 year old [24]. Among them, females accounted for most of these fall injury cases, and rates of cases were higher for females than for males for all age groups [24]. Furthermore, the rate of falls and associated injuries is even higher for older people in residential aged care and acute care settings [25]. In that regard, a study with older women in Australia reported that during 12-month follow-up period, 49% of participants fell, with 23% falling more than once [26].

Around 5% of all falls in community-dwelling older adults result in a fracture whereas 5 to 10% of falls result in serious soft tissue injury including head injury and joint dislocations [8, 10, 27-29]. A report of the Commonwealth Department of Health and Ageing in Australia showed that many of these injuries are severe leaving less than 50% of the older people able to return home after an episode of a fall [30]. This is an important data because the ones who are able to return to their homes, most often require long term care which demands substantial resources by aged care facilities [31].

2.3 Costs of Falls-Related Hospitalization in Australia

The health care costs associated with falls-related hospitalisation constitute a substantial proportion of the Australia health expenditure. The 2007–2008 Australian Institute of Health and Welfare (AIHW) falls report estimated the total cost of fall-related acute episodes of hospital care for older people at $648.2 million [32]. Further, estimates of the costs associated with injurious falls including lifetime costs exceed $1 billion per year [30]. These indirect costs are mainly due to incapacitation or premature death or costs borne by the family or community.

It has also been demonstrated that older people of lower socio-economic status have a higher rate of hospitalisation due to falls [33]. As such the Western and Northern suburbs of Melbourne, which comprise one of the areas of lowest income and socioeconomic disadvantage [34], would be an important area to target future interventions to prevent falls among older adults.

2.4 Risk Factors for Falls among Older Adults

There are several classifications regarding risk factor for falls. One of the most used classifications lists them as extrinsic (environmental) and intrinsic (within-subject) factors [35]. Several environmental factors have been identified to increase the probability of falls among older adults. These include the presence of obstacles (including rugs and carpets), slippery surfaces (e.g., in bathrooms), ascending or descending curbs and stairs, poor lighting and unsuitable footwear [36]. The intrinsic factors have been further divided into the following classes: Psychosocial and demographic factors (e.g., advanced age and female gender), postural instability (e.g., impaired gait and mobility), sensory and neuromuscular factors (e.g., reduced peripheral sensation and muscle weakness), medical factors (e.g., depression, dementia and stroke), and medication use (e.g., use of four or more different medications) [37].

Fuller [38] proposed another classification for the risk factors for falling which included the following factors:

- *Demographic*: older age, white race, housebound status, living alone;
- *Historical*: use of cane or walker, previous falls, acute illness, chronic disorders, medications;
- *Physical*: cognitive impairment, reduced vision, difficulty rising from a chair, foot problems, neurological changes, decreased hearing;
- *Environmental hazards and risky behaviours*.

Although these two classifications have proposed different nomenclatures for the possible factors causing falls among older adults, they have some similar factors being mentioned. One of the most important factors in common between these two classifications is the environmental one which is cited to be linked to increases in falls risk in older age. Hazards in the environment (e.g., tripping over objects, poorly fitting footwear, poor lighting, carrying heavy or bulky objects, narrow steps, loose rugs, and slippery floors) further contribute to the older adult increased risk of falling (i.e., 25%) [39]. Furthermore, the majority of falls in community-dwelling older adults happen when performing simple daily routines [40]. Activities like getting into or out of bed (16%), twisting or turning in bed (13%), getting onto or up from a toilet (13%) and putting socks, shoes or stockings on from a sitting position (10%) account for the majority of these falls [41]. Greater than 70% of falls in the community occur in the home [42].

Falls in older age happen for varied causes. The major reported causes are: accident or environment related (31%), gait or balance disorders (17%), dizziness (13%), drop attack (i.e., sudden fall without loss of consciousness, 9%) and confusion (5%) [43]. Others mentioned that prior history of falls, older age, functional impairment, cognitive impairment or dementia, use of a walking aid or assistive device, balance abnormalities, and impaired mobility or low activity level are risk factors for falls in older adults [44]. Abnormal gait or balance disorders have been reported as the most consistent predictors of future falls (likelihood ratio range 1.7–2.4) [45]. On the other hand, medications, visual impairment, decreased activities of daily living, impaired cognition and orthostatic hypotension did not consistently predict falls across studies with older adults [45]. This finding is, however, equivocal because previous falls, medications, impairments in strength, gait and balance were reported to be the risk factors most highly correlated with fall risk [46].

Most falls are associated with one or more identifiable risk factors [18] and the risk of falling has a direct association with the number of risk factors involved [8]. Risk factors such as postural hypotension (3%), visual disorders (2%) and syncope (0.3%) accounted for a very low proportion of falls in a review of 12 retrospective fall studies involving 3628 falls [43]. On the other hand, physiological factors, which are most often targeted by preventive programmes, have been highly associated with the risk of falls [8].

An important point about the physiological risk factors for falls is that they are also potentially modifiable [47]. Some examples of these physiological factors are muscle weakness, impaired proprioception, balance impairment, postural sway and reaction time [48, 49]. In fact, an accidental fall might be a consequence of impairment on one or a combination of these physiological factors which is, in turn, responsible for further decline in older people initiating a vicious downward cycle [50]. Furthermore, all progressive age-related changes affecting skeletal muscle mass, structure, composition and physiology can play an important role in the activation and maintenance of good health [50]. This finding is very important because lower extremity muscle weakness, which happens with ageing [51], has been strongly associated to the risk of having a fall resulting in injury [52]. Moreover, poor balance and gait or mobility performances have been shown to be associated with significant increased risk of mortality among older adults aged 75 and over [53]. These changes due to the ageing process may be relatively easy to identify among older adults because they may mostly present less endurance, compromised balance, slower gait speed, and difficulty performing simple tasks such as rising from a chair or stepping up a stair [50]. The three most common modifiable risk factors for falls reported are muscle weakness (relative risk ratio/odds ratio 4.4), balance deficits (relative risk ratio/odds ratio 2.9), and gait instabilities (relative risk ratio/odds ratio 2.9) [43, 54, 55]. Therefore, targeting these modifiable risk factors through structured and planned exercise programmes in the community could be an effective way to reduce the risk of falls among older adults and reduce the rate of decline among older adults [56, 57].

2.5 Consequences of Falls in Older Age

Falls are associated with psychological, social and physical problems leading to functional limitation, disability, loss of mobility, anxiety, depression, social isolation and poorer quality of life [58-61] . Around 20% of older patients with fall-related hip fracture die within a year after the episode [62]. After three years, this figure could reach 79% with men demonstrating higher rates of mortality than women [63, 64].

Falls and fall-related injuries are among the most common causes of decline in the ability to care for oneself and to participate in social and physical activities [65]. Falls which do not result in a serious injury increase the risk of skilled nursing facility placement by 3-fold if cognitive, psychological, social, functional, and medical factors are accounted for [66]. Experiencing a fall which results in a serious injury would then increase this risk by 10-fold [66].

Falls may also result in a post-fall syndrome which includes dependence, confusion, immobilization, loss of autonomy and depression [67]. The latter has been cited as a powerful factor in lowering the quality of life among older adults [68]. In addition, depressive symptoms are known to have considerable impact on well-being and to be associated with disability among older adults [69]. Increased use of medications after having a fall or being fearful of having a fall limits daily functioning [70]. All of this, in turn, is likely to result in further restriction in daily activities, further reductions in muscle strength, balance, and gait speed [71] and increased risk of future falls [67].

2.6 Current Interventions to Reduce Falls

Numerous fall prevention programmes for older adults have been developed and their effectiveness evaluated. Intervention programmes have either been multifactorial and multidisciplinary in nature or have focused on a single risk factor to prevent future falls.

2.6.1 Multifactorial Interventions

Multifactorial/multidisciplinary interventions have included a combination of community education, home hazard reduction, media campaigns, behavioural instructions, use of hip protectors, exercise programmes, eye surgery (cataract), adjustment to medications, home visits delivered by doctors, physiotherapists, occupational therapists and nurses [2, 72, 73].

2.6.2 Single-Intervention Approach

Single-intervention approach studies have mainly used some of the options listed above as a single preventive element such as home hazard assessment and modification, or exercise programmes (e.g., Tai Chi, strength training and strength training combined with balance retraining). In addition, dance [74], withdrawal of psychotropic medication, vitamin D supplementation (with or without calcium), pharmacological therapy and therapy using a cognitive/behavioural approach alone are other options that have also been used [10, 56].

2.6.3 Multifactorial versus Physical Exercise-Alone Interventions

In a recent meta-analysis comparing multifactorial versus physical exercise-alone interventions, exercise-alone interventions were shown to be about five times more effective in reducing falls compared to multifactorial ones [75]. Analysing the outcomes amongst single, multiple and multifactorial interventions, it has been concluded that group and home-based exercise programmes as well as home safety interventions reduce rate of falls and risk of falling [56]. The results of this recent systematic review updated the results of a previous systematic review which had found that exercise programmes were effective in reducing the risk of falling only [76]. Furthermore, results regarding the effectiveness of the multifactorial interventions in reducing the risk of falls and number of falls among older adults have been equivocal. A previous systematic review had reported that these interventions can reduce the rate of falls in older people living in the community but not their risk of falling [56] whereas a most recent Cochrane Systematic Review described that the multifactorial interventions were more effective in reducing both the risk of falling and the monthly rate of falls [76].

Multifactorial interventions, however, have an associated increase in cost [75] which could be a problem when implemented in places with limited resources. Moreover, such interventions could be potentially problematic to older participants. They may result in cognitive overload or conflicting information with participants having difficulty integrating the new routines into their daily life [77]. Consequently, the potential interaction among the different components of the interventions (confusion to participants or too many changes requested) may potentially lead to rejection of all interventions, decreased adherence and limited program uptake [78].

2.6.4 Exercise Interventions for Falls Prevention

Exercise programmes have been shown to be effective in reducing the risk of falling and the rate of falls [56] because they can improve muscle strength, flexibility, balance, coordination, mobility, proprioception, reaction time and gait [10]. Also, they can slow down functional losses expected with increased age [79]. Consequently, exercise interventions are able to improve quality of life and maintain functional independence in older adults [79].

However, the duration, mode, and intensity of these exercise interventions play an important role that contributes to their effectiveness. A previous meta-analysis identified that 50 hours cumulative exercise (i.e., with instructor plus prescribed home exercise) had a greater impact on reduction of falls than programs with a lower dose of exercise [57]. Greater fall prevention effect rate (i.e., reductions of 39%) are seen from exercise interventions that challenge balance and involve 3 or more hours/week of exercise [9]. Furthermore, it has been demonstrated that exercise intensity is also a greatly important variable to be considered [57]. Exercise interventions proposing more intense exercises, with higher frequency (at least twice weekly) and with the length of the program exceeding 25 weeks were shown to be the most effective in reducing the falls risks [80]. Such length should be considered as the minimal amount of time necessary for physiological adaptations in older people [80].

The components chosen to be targeted in exercise programmes (e.g., muscle strength and balance), play a role in the effectiveness in reducing the risk of falls and falls rate. Group and home-based exercise programmes, usually containing some balance and strength training exercises, effectively reduced falls rate and falls risk [2, 84]. Classes that included just gait, balance or functional training achieved a statistically significant reduction in rate of falls (i.e., falls per person year) but not in risk of falling (i.e., number of people falling (fallers) in each group analysed) [2]. Other authors reported that the most effective approach to reduce falls rate and falls risk includes multicomponent exercise programmes with strength and balance training and if possible also flexibility and endurance training [84]. Programmes containing two or more of each of these components are the most effective options in reducing rate of falls and number of people falling [56]. Interestingly, exercise programmes that focus only on resistance/strength training or walking, being performed in group or individually, have not been successful in reducing the rate of falls nor risk of falling [2]. Therefore, further research exploring the best combination and balance of components within these multicomponent exercise programmes is still needed [56].

Positive effect in reducing the falls risk and falls rate was also observed in interventions providing supervised group sessions. In fact, supervised group exercise, when at least including two different training components, decreased the rate of falls by 22 % (relative risk [RR] 0.78, 95 % CI 0.71–0.86) and the risk of falling by 17% (RR 0.83, 95 % CI 0.72 – 0.97) among community-living adults aged 60 years and over [84]. These positive effects of exercise programmes were found even among older adults with high risk of falling [84].

In addition, exercise interventions proposing functional-based exercise (i.e., exercises that mimic activities of daily living such as sitting and stand from a chair and stepping up and down stairs) and multitask exercise programmes (e.g., performing exercises while counting backwards) are also reported to prevent falls in older adults. Functional-based exercise programmes have been suggested to protect older and high-risk individuals from falling and that functional training provides an alternative to traditional exercise for fall prevention [85]. Furthermore, multitask exercise programmes have been shown to be effective in reducing 54% of the number of falls

(RR 0.46; 95%CI 0.27-0.79) among older adults 65 years and older who were at increased risk of falling [86].

2.7 How Active Are Older Australians?

Regular physical activity has long been known as an important factor for improving the general health, preventing the development of some diseases such as hypertension, heart disease, osteoporosis, degenerative arthritis, colonic cancer and diabetes mellitus, for improving mood and memory function, and promoting and helping to maintain a better social network [87]. However, most people, particularly older adults, are still reluctant in adopting a healthier lifestyle and make healthy changes part of their daily routine [88].

In 1998, a global leader in exercise and sports science, the American College of Sports Medicine (ACSM), produced some physical activity guidelines with the objective of increasing physical activity levels of a predominantly sedentary worldwide population and control the rise of a myriad of preventable diseases (e.g., hypertension, obesity and diabetes) [89]. ACSM until nowadays releases guidelines and position stands form the cornerstone of practice for exercise professionals worldwide. Their guidelines recommended that adults over 65 years of age do 30 minutes of moderate intensity aerobic, resistance, neuromotor exercises and/or sports activities five days a week or 20 minutes of vigorous aerobic, resistance, neuromotor exercises and/or sports activities 3 days a week [90]. Additionally, the ACSM recommends older adults perform 8 to 10 strength training exercises (with 10 to 15 repetitions on each set) two or three times a week. Regarding the neuromotor training, exercises involving balance, agility, coordination, and gait are recommended to be incorporated to their exercise program or it can be performed as often as the individual likes [91]. ACSM also suggests that the ones who are able to exceed the minimum recommendations, should do so. It is highlighted that these recommendations are only minimum requirements for one to maintain good health [90].

However, physical inactivity still accounts for 6.6% of the attributable risk for Australians' burden of disease [92]. Data from the 2014–2015 National Health Survey in Australia reported that only 24.9% of adults aged 65 years and over performed at least 30 minutes of exercise on five or more days in the last week [93]. Also, almost half of this population group (44.7%) had no days in which they exercised for more than 30 minutes. These data were relatively similar to proportions observed in the 2011-12 National Health Survey in Australia where 23.8% of older adults were reaching the physical activity guidelines and 45.8% were not performing any exercise [93]. Other authors also confirmed that only less than half of Australians aged 65 years and over engage in sufficient physical activity to a level that would produce some health benefit (i.e., accumulation of 150 minutes or more of moderate and/or 60 minutes of vigorous activity/week [94]). In agreement with these findings, a very recent study observed that the vast majority (85%) of Australian adults did not meet the full physical activity guidelines that incorporate both moderate to vigorous physical activity and strength training [95]. Older women were less likely than men to participate in regular physical activity, especially leisure time physical activity [96]. The proportion of older Australians classified as sedentary was slightly lower than in countries such as Canada and the United States [97]. Furthermore, if older adults' native language is taken into consideration, it has been reported that those who speak English as a second language exercise less than the general population [98]. Considering the prevalence of physical activity among Aboriginal and Torres Strait Islander people, the numbers were also significantly low with physical inactivity being in the top five risk factors contributing to their health problems [99]. Therefore, putting all these other factors together (i.e., being non-English speaker and indigenous people), the reported proportion for physical inactivity among older adults in Australia may have been even underreported.

2.8 Perceived Barriers to Falls Prevention Exercise Interventions

There is a vast number of studies in the literature making efforts to understand why older adults are, or are not, physically active [12, 100, 101]. Most times, even if invited to take part in complimentary falls-prevention interventions in the community, fewer than half of them would take up the opportunity [102]. It is clear that older adults have many barriers to exercise and becoming more physically active. This physical inactive problem among older adults clearly represents an important public health challenge [101]. Therefore, finding a way to increase the engagement of older adults in some sort of physical activity is paramount.

Barriers to exercise participation can be real or perceived and can represent significant potential obstructions to the adoption, maintenance, or resumption of it in older adults' routine [103]. Among older adults' barriers to participation in falls prevention interventions, literature has cited denial of falling risk, the belief that no additional falls prevention measures were necessary, practical barriers to attendance at groups (e.g., transport, effort, and cost), and a dislike of group activities [70]. Lack of motivation, illness/disability, lack of leisure time or lack of financial resources have also been reported as barriers to exercise participation [104].

Barriers to exercise participation can also be classified as environmental (e.g., crime rates, weather, no safe sidewalks, lack of transportation, location of the program being offered), motivational (e.g., a lack of will power, interest, or time to participate in such activities), symptom (fear of pain or shortness of breath and lack of energy) and personal (e.g., finding themselves too tired or ill to exercise) [101, 105, 106]. These barriers are associated with the amount of physical activity a person would engage in, i.e., the more of these barriers are present, the less likely they engage in some sort of physical activity [107]. Moreover, exercise behaviour and engagement in exercise programs can also be directly influenced by someone's beliefs [105]. For example, sometimes a person may say that he/she cannot exercise due to lack of time despite evidence in their life showing the contrary. Thus, this perception can strongly influence their exercise behaviour.

In order to develop effective strategies for increasing participation in exercise programs for older adults living in the community, it is critical to have a good understanding of the individual's perspectives and barriers which can strongly influence adherence to new and/or existent exercise programs. This is important as these barriers and personal factors can reduce the likelihood of this vulnerable population group from benefitting from exercise interventions (e.g., falls prevention interventions) not only due to low uptake but also due to low participation [108].

2.9 Adherence to Falls Prevention Interventions

Adherence to fall prevention programs in particular remains a major determinant of a successful intervention [108]. There is still a need to improve long-term adherence to physical activity, which is not a common habit for most of those aged 65 years and over [67]. In fact, a recent telephone survey in NSW has shown that older people's participation in strength or balance-challenging activities was only 21.0% (95% CI: 9.8–22.2) with only 5.3% participating in both forms (strength and balance-challenging activities) [11].

Participation in exercise or falls prevention interventions is actually very low, suggesting that older people may be reluctant to participate, or do not feel that interventions are sufficiently appealing or beneficial for them to take part in [70]. However, if the falls prevention context is changed or not emphasized as much, and the focus goes to other aspects such as social interaction and enjoyment, uptake and adherence to these exercise interventions may greatly improve. It has been reported that older adults are more likely to maintain their exercise participation in activities that focus on the enjoyment of exercise participation than in activities that rely primarily on extrinsic motivation such as the expectation of improved health and well-being or reduction of the risk of falls and number of falls [109].

Furthermore, it is difficult for some older adults to admit they are at risk of having a fall and that they need to take part in an exercise intervention aiming to prevent falls. Most older adults may not accept the idea that they are at risk of falling or, if they accept it, they never admit it publicly because this could undermine their status as competent and independent in the society [70]. Some older adults think that, once they admit they are fearful of falling, they may be labelled as old and frail person [110]. Moreover, others decide not to do anything about their risk of falling just because they believe nothing can be done in that respect [111].

Adherence to falls prevention exercise interventions may be also limited due to financial problems faced at retirement age. Older adults generally have reduced disposable income at retirement and having to pay to exercise may play a crucial role in their adherence [112]. Furthermore, a survey has indicated that older adults often choose low cost exercise habits such as walking, gardening and home exercises [113]. To encourage older adults to be physically active, an ideal exercise program would have to be easy to access (e.g., close proximity to their home, in a safe environment, and free of cost) and have knowledgeable staff conducting the sessions [114]. Therefore, the organization and implementation of community-based programs with none or low cost to participants rather than only home exercises could be a potential solution for the existent problem of low adherence to exercise interventions among older adults [115-117].

More recent studies have attempted to understand the role of organized community-based programmes as well as older adults' perceptions of the utility and appeal of these programmes [101]. However, a full understanding of the factors contributing to their adherence is still lacking [101] mainly in regard to older adults of diverse ethnic backgrounds and those who are socio-economically disadvantaged [118]. It is important to note that not only extrinsic factors (e.g., location, safety of neighbourhood and being supervised) play a role in the adherence to exercise programmes among older adults but also intrinsic ones such as someone's self-perceptions and beliefs.

2.10 Exercise Participation and Self-Perceptions among Older Adults

Regular exercise participation improves subjective well-being and quality of life among older adults mainly by delaying disease onset and premature death [119]. It has also been shown to be effective in reducing falls risk and rate of falls among this population group [2]. Additionally, regular exercise can improve physical self-perceptions and in some cases global self-esteem among exercisers which consequently can contribute to well-being and better mental health [119]. However, there is still limited evidence about the role and influence of global and physical self-perceptions on older adults' exercise participation.

Global and physical self-perceptions are part of the Self model which is multidimensional and hierarchical in nature [120]. The hierarchical nature suggests that self-esteem or global self-worth is at the apex. At the middle of the hierarchy are perceptions about the self in more general domains (e.g., physical, social, academic) and at the base of the hierarchy are the perceptions of behaviour and functioning in specific situations (e.g., health, strength). Global self-worth is assumed relatively stable over time with the lower levels more susceptible to change. It should also be acknowledged that self-perceptions are made against a particular internal or external frame of reference (i.e., the way a person perceives him/herself at a particular point in time) or ideal [121].

Physical and global self-perceptions have been shown to be important correlates of levels of physical activity in children and adolescents [21] and predict preventative health behaviours (including physical activity uptake) among older adults [22]. However, the role of self-perceptions in relation to physical activity uptake and its maintenance among older adults remains unclear. This is an important issue because older adults might be hesitant to try new behaviours because of their global and physical self-perceptions and beliefs on their physical abilities.

The study of self-perceptions and self-esteem is important because they are associated with poor health behaviours (i.e., physical inactivity and sedentary lifestyle) and there is clear evidence that exercise can change people's perceptions of their physical self and identity in a positive way [119]. However, in experimental studies, physical activity and/or exercise have rarely shown to produce more than a weak association with increases in mood and positive self-perceptions [122]. Moreover, it is unclear if this association is related to a specific age group (e.g., most studies evaluated these associations among teenagers or younger adults) or whether it is specific to the type of physical activity performed (e.g., sports related activities). It was suggested that the activity being offered would need to be a particularly powerful experience to instigate a big change in self-perceptions given that most research interventions are offered over a relatively short period of time particularly in relation to physiological adaptation to exercise [122]. In addition, what works for one population group may not work for others and the setting where these activities take place may also be important in the analyses of these relationships.

Equivocal results about self-perceptions among older adults are also observed because of the paradigm chosen to analyse them (i.e., quantitative vs. qualitative). Some studies use a quantitative approach to evaluate physical and global self-perceptions and their influence on variables such as fear of falling, quality of life and exercise uptake [123]. In limiting their analyses to a quantitative approach, valuable information may potentially be missed given that the subjective knowledge about the lived experience from these participants is not being thoroughly investigated and captured [123]. Therefore, mixing quantitative and qualitative information would provide a better understanding of the role of self-perceptions in older adults' adherence to interventions aiming to improve their fear of falling, quality of life, risk of falling and rate of falls, and this in turn, could better help in the implementation of these interventions. This information can also be further incorporated into the design of the intervention (e.g., group vs. home based) and help in the identification of the most appropriate environment for these interventions to be run (e.g., indoor vs. outdoor). Having a sound understanding and knowledge of these variables could potentially improve the long-term adherence and uptake of these exercise interventions among older adults.

2.11 Benefits of Outdoor Exercises

The evaluation of the relationship between the natural environment and human health and well-being seems to attract interest and attention [124]. In that regard, many organisations working within the public health and environmental sectors such as Parks Victoria and the British Trust for Conservation Volunteers [125, 126] have invested significant resources in initiatives which use the natural environment as a means of improving public health (Parks Victoria Walks and Green Gym, respectively).

Natural areas have been shown to promote public health in many different ways. For example, they help to stimulate people to be more active [127]. People who live close to coastal areas, beaches and inland water bodies appear to be more active [127]. Additionally, people who are more in contact with natural environments are more exposed to three major health benefits: reduction in stress; increased physical activity; and building of stronger communities [127].

Contact with nature has also been linked to other health benefits. A study found that people believe forest or park walks provides a better opportunity for stress reduction [128] at the same time that allows recovery from mental fatigue [129] and attention restoration [130].

Recovery from mental fatigue is mainly possible because nature is assumed to attract involuntary attention because of its fascinating qualities [128]. Regarding attention restoration, natural spaces facilitate the restoration of attention capacities which can be depleted by activities demanding prolonged and effortful attention [128, 131]. Furthermore, outdoor activities show greater improvements in mental health compared to indoor [132]. Finally, exercising outdoors has been reported to contribute to significant improvements in mood, self-esteem and reduce levels of depression among older adults [133].

Some studies indicated that people tend to enjoy more to be in places with natural features such as trees, vegetation, and water, compared to environments that lack such features [134] and that they prefer and find it more attractive to walk in a natural environment rather than a more urban environment [135]. In addition, outdoor exercise settings providing people with sunlight, trees, water, clouds, fresh air, and bird song have been reported to be more fascinating and appealing to those exercising [136]. All these aesthetic characteristics presented in outdoor environments are believed to amplify the psychological benefits of exercise to a greater degree and, in turn, encourages people to exercise more [136]. This mainly happens because these characteristics promote a reduction in stress and anxiety, renewal of the ability to direct attention, and other forms of restoration on the top of the benefits of the practice of exercise itself [136].

Outdoor activities also offer other health benefits. Differently from indoor activities, engaging in physical activity outdoors promotes more exposure to sunlight needed for maintenance of sufficient vitamin D levels [137]. Older adults that exercise outdoors more often are more exposed to long term health benefits [138] mainly because most of them tend to have Vitamin D deficiency which is related to chronic conditions such as heart disease and poor bone health [139]. Exposure to nature during outdoor activity has also been shown to promote changes in cardiovascular, endocrine and autonomic function which suggests a psychophysiological impact of nature and green exercise [124]. Finally, a substantial body of evidence can be found indicating that outdoor exercise offers genuine benefits in treating or even avoiding the onset of obesity, diabetes, depression and many other conditions [127, 140].

In summary, the synergistic combination of exposure to nature and practice of exercise can be a powerful tool to help fight the growing incidence of physical inactivity and a whole myriad of mental, physical and metabolic silent diseases [137]. Thus, it is believed that focus should be given to initiatives targeting this element. In that regard, an outdoor senior exercise equipment/area can be a potential successful exercise option for older adults to improve their sedentary behaviour, improve quality of life and well-being as well as reduce their risk of falling.

2.12 Outdoor Senior Exercise Park – an innovative approach for active ageing

The outdoor senior exercise park, which consists of outdoor exercise equipment with multiple stations, was originally introduced in Europe in 2008 as a novel purpose-built exercise park designed to improve muscular strength, joint range of movement, flexibility, coordination and balance through active fun games and challenging but safe activities (see Fig. 1). This initiative aims to inspire older people to be more active and adopt a healthier lifestyle. Such indoor and outdoor exercise parks are widely available in Finland, Spain, United States, Japan and China with only few available in Australia.

The concept of the dynamic exercise park has the potential to address many of the previously identified key falls risk areas: 1) biological risk factors (physical, cognitive and affective capacity) 2) socio-economic risk factors (social interactions, costs, community resources) 3) behavioural risk factors (lack of exercise). With this novel concept, older adults might feel more inclined to exercise given that these playful and purposeful activities are also functional and practical to what they do in their daily living activities [141]. Furthermore, older adults value initiatives that can help them to maintain independence, autonomy, and confidence, and, consequently promoting a more positive self-identity [142].

Fig. 1: Lappset's exercise park for senior population

Preliminary evaluation of the use of the exercise park for older people produced by The Netherlands Organization (TNO) in 2008 suggested the purpose-built exercise parks may be safe and acceptable to older people [14]. This internal report also reported a high attendance rate (92%), reduction in fear of falling and improvements in muscle strength and balance among the small number (n=13) of participants [14]. Although the results of this report are promising, no evidence-based research using a well-established scientific testing methodology exists in order to evaluate the effectiveness of the exercise park in improving physical health, and psychological well-being in older adults. Therefore, further research is needed with a larger sample size and a longer intervention period to determine the feasibility and effectiveness of the senior exercise park program on physical outcomes, health-related outcomes and well-being of community dwelling older adults.

Given the potential benefits of this novel outdoor exercise initiative for older adults, the general aims of this thesis were to investigate the feasibility and effectiveness of an 18-week exercise program using the senior exercise park in reducing the risk of falls (i.e., improve muscular strength, balance and physical function) among older adults. To achieve this, the present thesis evaluated the effect of an 18-week exercise intervention on physical measures (e.g., muscle strength, balance and physical function) as well as health related measures such as reduction of fear of falling and improvement in quality of life (Chapter 4). Moreover, to evaluate the feasibility of this exercise initiative, the acceptability, barriers, enablers, perceived benefits and outcomes as well as recruitment rate, adherence, safety and adverse effects were also assessed (Chapter 4 and 5).

Moreover, for a more holistic approach about the effects of an exercise intervention using the senior exercise park, this thesis also provided further insight regarding a broader range of older adults' global and physical self-perceptions changes as well as social activity participation change after participating in the 18-week outdoor senior exercise park intervention (Chapter 6). Finally, this thesis explored whether the physical, and health related outcome measures previous studied can be sustained (carry-over effects) 8 weeks after exercise intervention completion (Chapter 7).

Chapter 3 –Methodology for Study of the Feasibility and Effectiveness of Senior Exercise Park Program (Study Protocol)

Statement of contribution to co-authored published paper:

This chapter includes a co-authored published paper (as published in the journal) which explains the methods, design and outcome variables investigated for the evaluation of the feasibility, effectiveness and acceptability of the senior exercise park program as published in the journal. The bibliographic details of this co-authored paper including all authors involved are:

Sales, MP, Polman, R, Hill, KD, Karaharju-Huisman, T, & Levinger, P, *A novel dynamic exercise initiative for older people to improve health and well-being: study protocol for a randomised controlled trial.* BMC Geriatrics. 2015. 15(1):68.

My contributions to this paper involved the data analysis, designing, writing and preparation of the draft as well as the final version of this document. I responded to the comments raised during peer review process and made final amendments prior to publication.

21 Apr 2017

Myrla Sales

21 Apr 2017

Principal Supervisor: Associate Professor Pazit Levinger

3.1 Introduction

Falls are a leading cause of death and disability among older adults [76]. About one third of people aged 65 years or older fall at least once a year [2, 76]. In 2013, Australia had 14% of its population aged 65 years and over [143] with approximately 10% have multiple falls [5] and 20% of those who fall experience injuries requiring medical attention [2]. In 2011-12, there were 88,386 fall related hospitalisations in Australia for people aged over 65 years, with the most common injury being hip or other lower limb fracture [6]. Hip fractures in particular are associated with high level of mortality and morbidity, with recent studies reporting that 20% of hip fracture patients die within 12 months of injury [144], and over half do not regain pre-fracture mobility or large muscle group abilities up to two years after the fracture [145].

Most falls are associated with one or more identifiable risk factors [7] and the risk of falling has a direct association with the number of risk factors involved [8]. Physiological factors, such as lower extremity muscle weakness, gait and balance impairments and functional impairments, have been highly associated with the risk of falls and are most often targeted by preventive programmes [8]. Therefore, targeting these modifiable risk factors through exercise programmes seems to be a suitable way to reduce the risk of falls [2, 146].

Exercise programmes have been shown to be effective in reducing the risk of falling and the rate of falls [146] as they can improve muscle strength, flexibility, balance, coordination, proprioception, reaction time and gait [10]. These positive outcomes have been observed even in the very old and frail [10]. A meta-analysis identified that 50 hours cumulative exercise (irrespective of exercise frequency) is needed to reduce the risk of falls [57]. A recent telephone survey applied in NSW has shown that older people’s participation to strength or balance-challenging activities was 21.0% (95% CI: 9.8–22.2) with only 5.3% participating in both forms (strength and balance-challenging activities) [11]. Thus, there is a need to improve long-term participation in physical activity, which is not a common habit for most older individuals [67].

The “exercise park for older people” was originally introduced in Europe in 2008 as a novel purpose-built exercise park designed to improve muscular strength, flexibility, coordination and balance through active fun activities. The exercise park aims to inspire older people to be playful, to exercise, and to challenge their bodies, which can lead to a more active and healthier life style. Such indoor and outdoor exercise parks are widely available in Finland, Spain and China with only few operating in Australia. Preliminary data from The Netherlands suggests the purpose-built exercise parks may be safe and acceptable to older people, had high attendance rates, reduced fear of falling and improved muscle strength and balance among participants [147]. However, no evidence-based research exists that demonstrates the effectiveness of the exercise park in improving physical health, psychological well-being or independence. Although these results are promising, further research is needed with a larger sample size and a longer intervention period to determine the effectiveness of the exercise park program on physical and psychological outcomes, well-being and independence of older adults, as well as determining the feasibility and acceptability of this type of program in the Australian community.

Therefore, the aims of this study are (1) to evaluate the effectiveness of such an exercise park in reducing the risk of falls and (2) to evaluate what other benefits, including psychosocial, functional and physiological, can be achieved by using this specific exercise park for 18 weeks with a structured and progressive program in community dwelling older adults using a randomised controlled trial design and (3) what benefits are sustained eight weeks after completion of the exercise park program.

3.2 Methods

All procedures involved in this trial will be conducted in compliance with National Statement on Ethical Human Resource and the Australian Code for the Responsible Conduct of Research. Ethical approval has been obtained from the Human Research Ethics Committee from Victoria University, Melbourne (Application ID. HRE13-215). The study was design according to the Consolidated Standard of Reporting Trials (CONSORT) guidelines and publications associated with the trial will be reported according the CONSORT 2010 Statement [148, 149]. This trial was retrospectively registered with the Australian New Zealand Clinical Trials Registry - Registry No. ACTRN12614000700639 on the Jul 03rd 2014.

3.2.1 Design and Setting

This study will be a parallel randomised controlled trial (RCT) with pre and post intervention design (outcome assessments at baseline and at 18 and 26 weeks after participation commencement) comparing an exercise park intervention program for older people with a control group, aiming at evaluating the effectiveness of an exercise intervention using an exercise park specifically designed for older people in reducing the risk of falls.

3.2.2 Participants

One hundred and twenty older people living in the community aged between 60 and 90 years old who have had one or more falls in the previous 12 months or who are concerned about having a fall will be recruited. Participants who are generally active and independent in the community with no more than a single point stick used for regular outdoors walking (at least three times per week) will be included. The aim in these inclusion criteria is to target those with mild falls risk, but who remain relatively active, using a health promotion and prevention approach.

Older adults will be excluded from this study if they have: 1) any uncontrolled non-musculoskeletal conditions that would make testing difficult and uncomfortable, such as chronic obstructive airways disease and congestive heart failure; 2) a pre-existing neurological or orthopaedic condition that affects lower limb strength (e.g.: polio, stroke); 3) any of the following foot conditions: partial foot amputation or ulceration or foot fractures; 4) any uncontrolled musculoskeletal conditions that may affect ambulation (rheumatoid arthritis, gout, etc.). Participants with heart problems (e.g. chest pain (angina), heart murmur, heart rhythm disturbance, heart valve disease or heart failure) will be required to obtain a medical clearance from their general practitioner in order to participate in this study. Participants with any documented medical condition or physical impairment that is judged by the medical practitioner to contraindicate their inclusion will be excluded.

3.2.3 Recruitment and Randomization

Participants will be recruited from Melbourne suburbs. Local senior organizations, retirement villages, community centres, senior clubs and associations in the areas around the park location will be contacted for recruitment purposes. Participants will be also recruited via community health promotion events and advertisement in local newspapers, magazines and online social networking media. Participants will be informed about the project by posters placed in healthcare facilities and places with high circulation of senior citizens and mail-out advertisements to health care practitioners in Melbourne. Participants will be randomly allocated to one of the following groups: (1) Exercise Park Intervention Group (EPIG) or (2) Control Group (CG). Block randomization stratification by gender will be undertaken, so that blocks of 12 participants will be recruited at a time, randomized into one control group of six participants and one exercise groups of six participants (Fig. 2). To accommodate couples (e.g. partners/married couples) participation, randomisation by couple will also take place. Assessors will prepare the envelopes with six paper codes (three exercise intervention and three control group)

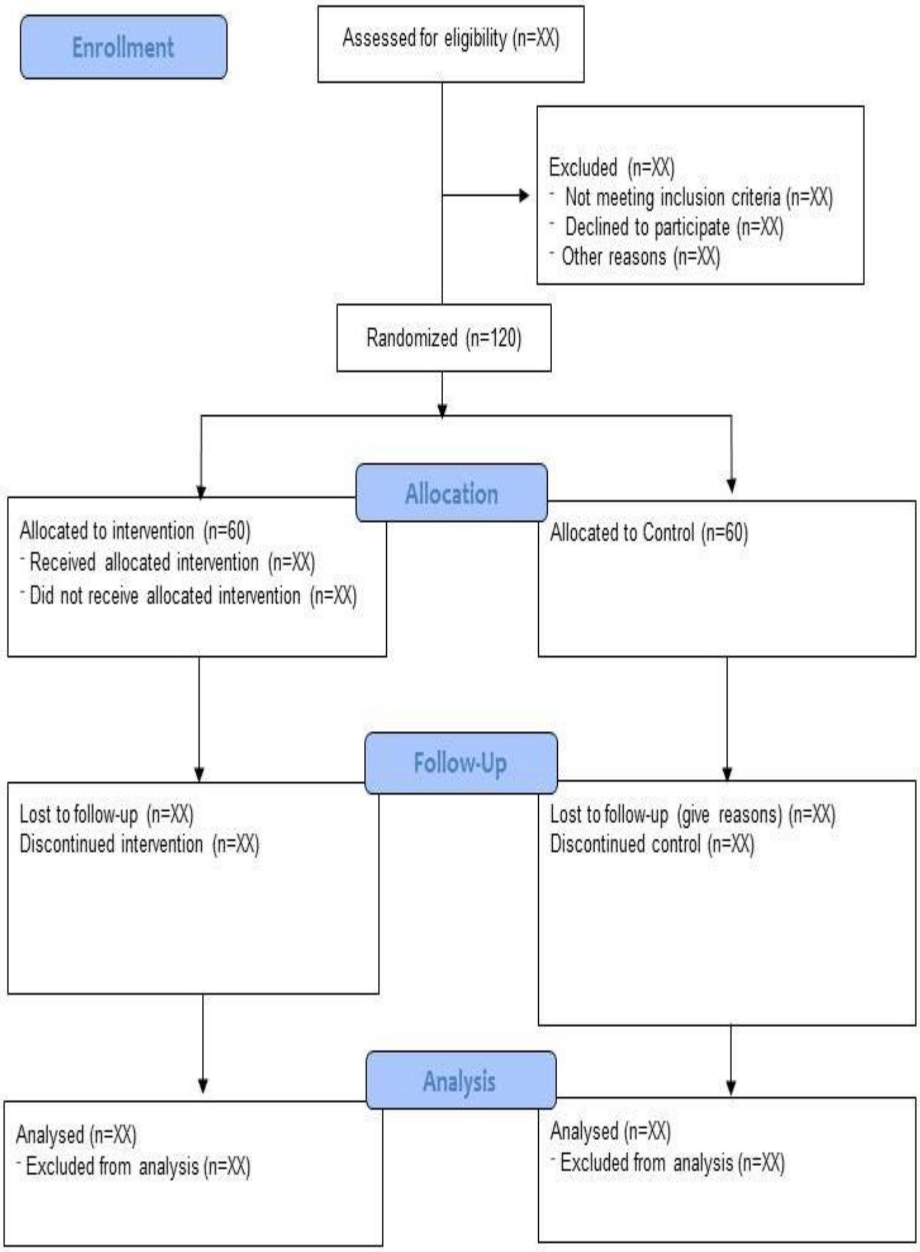


Fig. 2: Consort flow diagram of recruitment and randomization

which will be added to opaque not concealed envelopes. There will be three envelopes: one for couples, one for females and one for males. Participants will be asked to pick one paper from their respective envelope and the picked paper will assign the participant to either the exercise intervention group or control group. Recruitment will be undertaken over a period of 14 months to achieve a sample size of 60 participants in each group. Assessors and participants will not be blinded to their respective group allocation (EPIG or CG).

Participants from the EPIG will undergo an 18-week exercise intervention. The exercise sessions will be provided two times a week (each class approximately 1 to 1.5 hours duration) and will be supervised by a qualified physiotherapist or an accredited exercise physiologist. Each session will consist of 5-10 minutes warm-up exercises, followed by 45-75 minutes on the equipment stations, and will conclude with 5-10 minutes of cool down exercises. The exercise classes will include 6-8 participants and will be circuit-based with the warm up and cool down exercises being performed in a group and the core session being carried out in training pairs. Participants will be performing exercises that focus on strength, balance, coordination, mobility and flexibility as detailed in Tables 1 to 5. Exercisers will be paired in stations and an exercise session can include up to eight stations (See Table 6). The intervention program will be carried out at St Bernadette's Community Respite House, with no cost to the participants.

Participants in the CG will be advised to continue with their usual daily activities and will be meeting the research team every two weeks to take part in some social activities (nine meetings of two hours duration over 18 weeks of intervention). Participants from both groups will be tested at the following timelines: baseline, at the end of the intervention period (18 weeks) and two months after that (26 weeks after intervention commencement).

3.2.4 Treatment Preference and Credibility/Expectation

Research has shown that participants who are allocated to their preferred treatment achieve better outcomes than those who do not receive their preferred treatment, despite the randomisation process resulting in equivalent baseline outcome measure scores [150]. To address this issue, participants will be asked if they have a preference for one of the two groups they can be allocated to (documented as control group, exercise intervention group or no preference). However, their response will not influence their randomised group allocation [151]. It is expected that this approach conserves all the advantages of a randomised design. In addition, it enables the interaction between preference of participants and outcomes to be quantified in later stage of analyses [152].

3.2.5 Outcome Measures

Socio-Demographic factors (such as age, gender, education and previous occupation), medical conditions, medications currently prescribed, main surgeries and medical procedures undergone, smoking habits as well as alcohol consumption will be obtained via a structured questionnaire. Anthropometry will include body weight and height. Height and weight will be measured using a stadiometer and digital scales respectively, and body mass index will be calculated as weight (kg) / height (m^2).

3.2.5.1 Primary outcome: The Balance Outcome Measure for Elder Rehabilitation (BOOMER)

Due to the importance of balance in preventing falls, and given that balance is multi-dimensional, a test battery that incorporates a number of key domains of balance (static and dynamic balance, including measures of stepping, reaching and turning, that are commonly involved in falls) will be used as the primary outcome to assess the effectiveness of this novel purpose-built exercise park in improving several physiological, biomechanical and psychosocial factors associated with the risk of falls. The Balance Outcome Measure for Elder Rehabilitation (BOOMER) is a multi-item balance measure, which comprises 4 well validated clinical measures (step test [153], timed up and go (TUG) [154], functional reach (FRT) [155], and static standing balance [156]) [157, 158], and will be used as the primary outcome measure. The four individual components of the BOOMER can be scored individually or as a composite score and will be described as follows:

- Functional Reach Test [155] - the participant will be asked to stand next to a white board with feet hip width apart and closed fist, and extend their dominant arm horizontally at approximately 90° then reach as far as possible without taking a step or losing their balance. Lines will be drawn to mark the initial position of the participant's arm (zero position) and the reach forward position. The difference between the two marks will be measured [155]. There will be no attempt to control the participant's method of reach apart from making sure that participant is not twisting their body to achieve a further reach. Each participant will be given one practice trial and the best of two test trials will be used for the assessment.
- Static Balance Standing - For the static timed standing with eyes closed and feet together test, the participant will be asked to stand still on the floor with shoes on and eyes closed. The result will be recorded as a sum of three trials on which the participant can stand on this position. However, if the first trial records the maximum score of 30 seconds, then the subsequent two trials will be automatically scored as 30 seconds as per original procedure [156, 159].

- Step test - The step test is a measure of a dynamic single limb stance task [153]. Using a 7.5-cm high block, the participant will be asked to place his/her foot onto the top of and back to the floor as many times as possible in 15 seconds [153]. Participants will be given time to practice (around two correct cycle of steps) and one formal trial will be performed on the dominant leg.
- Timed Up and Go test - The Timed Up and Go test is a dynamic and functional performance measure of overall mobility, and balance [160, 161]. This test also evaluates the ability of an individual to turn 180° while maintaining the upright position and the ability to maintain the upright standing position immediately after transition from a seated posture [161]. The participant will be instructed to stand from a standard 43cm high armless chair, walk to a cone placed 3m away from the chair, turn around the cone and return back to the chair and sit. Participants will be asked to perform one practice trial and four testing trials. The testing trials will include two comfortable/preferred speed [161] and two fast speed Timed Up and Go tests [162]. The best time of each of the two speeds will be used for analysis. However, to compose the BOOMER measure, only the comfortable speed trial will be used. Participants will be allowed to use a gait aid if one is used routinely for indoors walking.

3.2.5.2 Secondary Measures

The following functional tasks and psychosocial variables will be assessed:

(1) Hand grip strength test [163] will be used to measure muscle strength. Hand-grip strength is a simple, reliable, inexpensive surrogate of overall muscle strength

and a valid predictor of physical disability and mobility limitation [164]. Using a TTM digital hand dynamometer (Mentone Educational Centre, Melbourne, VIC), participants will be asked to perform two maximum force trials with each hand and the best score of two attempts will be recorded. Participant will be seated on a 43cm high chair, feet flat on the floor, with shoulder adducted and neutrally rotated, elbow flexed at 90° and forearm in neutral and the wrist between 0 and 30 degrees extension and between 0 degrees and 15 degrees ulnar deviation [165]. The maximum values of the left- and right-hand grip measurements will be summed and be used for the analysis to remove consideration of hand dominance [163].

(2) Two minute walk test will be used to assess exercise tolerance [166] and functional mobility [167]. Improvement in distance walked within the test interval is attributed to improvement in cardiac output, in mechanics of ventilation, or in muscular conditioning [168]. Participants will be asked to walk for 2 minutes on a demarcated area at a comfortable pace and the maximum distance achieved will be recorded. Participant will be allowed to use their gait aid if regularly used for indoors walking.

(3) Lower limb strength will be assessed via the sit-to-stand test [169] and measurement of the strength of the knee extensor muscles using a purposely built force transducer [49]. The sit to stand test is a simple test used to measure mobility and lower limb strength [169] and is also included in fall risk assessments [170, 171]. Participants will be asked to stand from a 43cm high chair as many times as possible for a period of 30 seconds without any assistance of the assessor. Participants will be asked if they need their hands to assist them in standing up from the chair and this information will be recorded for further analysis. Otherwise, arms will be kept to the side of their body during the test.

The strength of the knee extensor muscles of both limbs will be measured with a purposely built force transducer which will be attached to the participant's leg using a webbing strap with a Velcro fastener. The participant will sit on a tall chair with a strap around the lower leg 10 cm above the ankle joint, and the hip and knee joint angles will be positioned at 90 degrees. The distance from the knee joint to the strap around the ankle will be measured with a tape measure. This measure will be used for the calculation of torque (i.e. force [N] distance [m]). The maximum voluntary contraction will be assessed during an isometric knee extension. Participants will be asked to perform three maximum voluntary contractions trials for each leg. The contractions will last up to five seconds each, with a rest period of one minute between each trial. The force data will be stored on a portable computer. The best performance of the three trials will be considered as the maximum torque for each side.

(4) Spatio-Temporal Gait Parameters: Measures of stride dynamics and gait variability have been shown to identify fallers in older adults with gait limitations and those with a history of falls [172, 173]. Assessment of walking speed, stride length, stride width and double limb support will be performed with the use of the GaitRite® system (CIR System, Inc, Harverton PA) instrumented walkway system (active length of the mat: 8.75m). Participants will be asked to start from a point 3m in front of the mat and will stop on a point 3m behind the mat. Approximately 10 strides per participant are required to achieve reliable mean estimates of spatio-temporal gait parameters including velocity, stride and step length, and step and single support time [174, 175]. Therefore, seven walks will be recorded to allow sufficient data to be collected. Multiple practice trials will be given until participants feel comfortable and will be walking with consistent velocity. This will be followed

by seven testing trials which will allow sufficient number of strides to be recorded. Participants who use a gait aid for indoors walking will be allowed to use it during the tests. Participants will be wearing flat shoes during the test.

(5) The following questionnaires will be used to evaluate health related quality of life measures and psychological or psychosocial measures:

a) *The Short Form (12) Health Survey Version 2 (SF-12v2™)* is a 12-item questionnaire which evaluates the individual health status over eight domains including vitality, physical functioning, bodily pain, general health perceptions, physical role functioning, emotional role functioning, social role functioning, and mental health [176]. The SF-12v2™ has been given preference for use among older people (compared with other longer versions of measures of quality of life such as SF-36) because of its brevity. [177]. Most questions use a five-value response option (all of the time, most of the time, some of the time, a little of the time, and none of the time) and some a three-value response option (yes, limited a lot, limited a little or not limited at all). Physical and Mental Health Composite Scores (PCS & MCS) are computed using the scores of twelve questions and range from 0 to 100, where a zero score indicates the lowest level of health measured by the scales and 100 indicates the highest level of health [176].

b) *The Incidental And Planned Activity Questionnaire (IPAQ)* for older people will be used to assess the physical activity level of the participants [178]. The IPAQ is a self-report questionnaire that covers the frequency and duration of several levels of planned and incidental physical activity in older people. Planned activities (6-items) include planned exercise or walks whereas incidental physical activities (6-items) include day-to-day activities like housework or gardening. Total hours per week spent in both incidental and planned physical activity will be obtained by multiplying frequency scores and duration scores. Summation of the incidental and planned physical activity hours per week will also provide a total activity score. The IPAQ has been shown to have good test-retest reliability and concurrent and face validity [178]. The IPAQ is relatively short and easy to complete by older individuals and has been used previously in studies of fall risk factors and prevention programs in older people [179-181].

c) *The falls efficacy scale (Short FES-I)* questionnaire will be used to record fear of falling [182]. The FES-I consists of 7 items using a Likert scale that assesses the participant's level of concern regarding the possibility of falling when performing certain daily activities. Items are scored from 1 = not concerned at all to 4 = very concerned. The total score ranges from 7 (not concerned) to 28 (severe concern) where higher scores are associated to a greater fear of falling [182]. The test–retest reliability of the Short FES-I is good (r = 0.92) [182].

d) *Social activity participation* will be measured with a 10-item questionnaire which was derived from a measure of social functioning [183] and has been previously used to measure social participation in people who had repeated falls [184]. Participants will be asked to record the number of times in the previous two weeks that they have participated in 10 categories of social activities including: gone to church, visiting friends and family, gone to concerts, plays, or sporting events; gone to fairs, museums or exhibits; and attended meetings, appointments, classes/lectures. Questions use a five-value response option (1 = less than once/week; 2 = once/week; 3 = twice/week; 4 = 3–6 times/week and 5 = every day). A summary score of social participation was calculated by adding the value of the answers the participant reported to have undertook on each of the 10 activity categories during the period in question (two weeks). Higher scores are associated with a higher level of social activity (values range from 10 to 50).

e) Physical self-perceptions will be measured using the *Physical Self-Description Questionnaire (PSDQ) – Short Form* [185]. The PDSQ is a 40-item questionnaire scored from 1 (false) to 6 (true) and consists of 11 factors: Health, Coordination, Activity, Body fat, Sport, Global Physical, Appearance, Strength, Flexibility, Endurance and Global esteem. The PDSQ has been shown to have good test-retest stability over a 3 month period (r = .81 to .94) strong factorial structure and discriminant and convergent validity [185].

f) *Falls and physical activity calendar* - Participants will be requested to record any falls and physical activity or exercise experienced using a monthly calendar for 12 months from the baseline assessment. At the end of each month the calendar will be returned to the researchers in a reply paid envelope. If the calendar is not returned within two weeks of the end of a month, the participant will be followed up with a phone call. For this study, a fall will be defined as "inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or other objects" [67] and this definition will be explained to the participant to make sure they fill in the calendars accurately.

3.2.6 Qualitative Data

Participants allocated to EPIG will be interviewed by an experienced qualitative researcher at the end of the intervention period (18 weeks). An interview guide (see Additional File 1 – Interview Guide) will explore the participant's experience with the project including reasons to volunteer to the project and their experiences with the training program (staff supervision, frequency, duration, progression of exercises, level of difficulty, changes to their life in general and general level of satisfaction). Only participants assigned to the exercise intervention group will be interviewed. In interviewing these participants, we aim to be able to identify the positive and negative elements of the exercise park program perceived by the participants, as well as the main participation barriers which can impact on the adherence and acceptability of the intervention. The interviews will be conducted on an individual basis by a researcher independent to the intervention. All interviews will be digitally recorded and transcribed verbatim. The interviews will be analysed using a thematic analysis approach [186]. Data will first be coded to identify and label text to the participants' experience of the exercise park using both an inductive and deductive approach. These codes will then be placed into overarching themes. Inter-rater reliability will be examined by an independent coder on all of the themes and subthemes by reviewing a random sample of 10% of all the excerpts relating to each theme and sub-theme with any differences in coding discussed between the coders [187].

3.2.7 Feasibility

As the senior exercise park initiative is a new concept to the Australian older community, feasibility will be assessed and will be defined as the number of participants recruited and retained over the recruitment period, overall adherence and seasonal adherence, safety and adverse effects and number of sessions cancelled due to unfavourable weather conditions. In addition, the qualitative data collected via interviews of EPIG participants will be taken into account for feasibility purposes as they might more clearly show participants' perceptions of this kind of initiative.

Overall adherence to the exercise program will be defined by the number of sessions attended: 100% adherence if participant attended 35 sessions or 9 sessions of social meetings. EPIG or CG participants' participation and attendance will be recorded via a spreadsheet diary and will be collected respectively by the exercise supervisor of that participant on each specific session or by the principal researcher. Physical activity calendars will be used to monitor if EPIG or CG participants have participated in any other physical activities during their participation in the study. Reasons for participants missing sessions will be documented on the spreadsheet diary. Participants will be given a phone call in case they miss two consecutive sessions without any communication with any exercise supervisors.

Considering that the exercise sessions are held outdoors, this study intends to investigate if the participants' adherence would be influenced by weather conditions during the four seasons in Melbourne. Seasonal adherence will be recoded as adherence over Summer (December to end of February), Fall (March to end of May), Winter (June to end of August) and Spring (September to end of November). Also, the number of sessions that were cancelled due to rainy, windy and excessively hot days (above 37°C) will be recorded given that these conditions would potentially put participant's safety and health in risk.

Safety and adverse effects will be measured by the number of falls incidents that occur during exercise sessions, and will be recorded via an incident report form (treatment needed post-incident and related lesions or injuries). The circumstances surrounding the fall (e.g. muscle fatigue, dizziness) will be recorded. EPIG participants will be also asked in the following session (48 hours) to report if they experienced any uncomfortable delayed muscle soreness or fatigue post-exercise that limited them from doing their daily tasks such as ascending and descending stairs, rising from a chair, and carrying shopping bags. The following question will be used: "Did you experience any muscle soreness after the session that limited you from doing your normal daily activities such as carrying shopping bags, rising from a chair or putting a t-shirt on?".

If they answer “yes” the muscle soreness event will be recorded on the participant’s spreadsheet diary.

3.2.8 Community Partner Organizations

An important aspect of projects of this nature is the identification of the community partner organizations that can help with personnel, infrastructure and logistical matters needed for its successful running. A key element of the design of this project is to conduct it in the community and therefore create a better platform for research translation. Therefore, a number of community organizations with a focus on older people’s health promotion and specialised care were approached. These community organizations were mainly selected based on the nature of the work they have been involved in with this specific population group. Two community organisations: Catholic Homes and Gateway Social Support Options have partnered to collaborate in this research project. Catholic Homes provided the infrastructure and land for the equipment installation and allow for the exercise session to be conducted in the community setting. Gateway Social Support Options is a community-based organisation with over 200 older people living in the western suburbs of Melbourne. Gateway Social Support Options will provide access to its members for participant recruitment.

3.2.9 Exercise Park

The senior exercise park used on this project was provided in-kind by Lappset (Fig. 1) and it was installed at the St Bernadette's Community Respite House in Sunshine North. The exercise park consists of a number of components and stations that aim to work on the following aspects of physical performance: upper body mobility and fine motor skills, balance and coordination, lower limb and upper limb strength, stretching and flexibility (Table 1-5).

3.2.10 Familiarisation and Exercise Intensity

A familiarisation session will be organised for each participant prior to commencement of the exercise program. The exercises will follow the guidelines of the Australian Position Statement of exercise for falls prevention [3]. Participants will be introduced to the 10-point Borg Rating of Perceived Effort (RPE) scale [188] at their familiarization session.

The initial level of the exercises difficulty will be tailored to the capabilities of the participant with the primary consideration of safety. Adjustment of the exercises (i.e. increase in intensity and difficulty) will be made based on the participant individual progression. RPE will be used to determine the intensity of each exercise where participants will be encouraged to exercise with a RPE between 4 and 7/10. New exercises will be gradually introduced to the participants every 1-2 weeks (See Table 7). A participant will progress to the next level of exercise when an RPE of below 4/10 (‘too easy’) will be reported (Table 1-5).

3.2.11 Individual and Group Exercise Progression

Each station will include two exercises and will be performed twice by each participant. Two participants will be allocated in each station such that each participant will perform one at a time and will swap over (See Table 6). However, a participant can be exercising only with their exercise supervisor in case there is an uneven number. Participants will have different pairs and exercise supervisors on each session to stimulate social interaction. Participants will be given a resting period of 30-60 sec which will be adjusted according to program progression as detailed in Table 8. The duration of each exercise will also increase based on program progression (Table 8). Rest periods between exercises will be used to discuss about difficulties and to provide further feedback. Participants will be allowed to have as many breaks as necessary to keep them performing the exercises with good technique and proper form. As some exercises such as step-ups on platform, ramp + walking through a net, and taps onto a platform can be more challenging to some participants due to the platform height, wooden blocks (L 70cm x W 40cm x H 10cm) will initially be used for these participants. The same blocks will be used to make some exercises such as push-ups, pull-ups and sit to stand a bit more challenging to participants (Fig. 1).

Table 1: Strength exercises to be performed using the senior exercise park with their respective levels of progression.

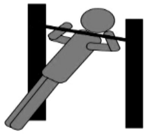
Exercise	*Description*	*Functional Relevance*	*Progressions*
Push-up bar 	Participant pushes body up away from the bar and brings it down towards the bar.	Strengthens arms, back and core muscles.	Standing nearly perpendicular to the bar: Level 1 – Wide grip. Level 2 – Narrow grip. Level 3 – Wide grip standing on a 10cm high block*. Level 4 – Narrow grip, standing on a 10cm high block* Level 6 – Narrow grip, hand release. Level 7 – Narrow grip, front knee tucks. Level 8 – Narrow grip side knee tucks. Level 9 - Perform the push-ups with 1 hand. Hand on shoulder line.
Modified Pull-Ups 	Participant pulls body up towards the bar.	Strengthens arms, back and core muscles.	Level 1-3 – Hands narrow (undergrip), increase distance from the bar (3 distances 3 distances determined by a line on the floor). Level 4-6 – Hands wide (undergrip) – increase distance from the bar (3 distances) Level 7-9 – Hands narrow (overgrip) – increase distance from the bar (3 distances). Level 10-12 – Hands wide (overgrip) – increase distance from the bar (3 distances). If the participant reaches RPE 4/10 again, the wooden 10-cm high block can be introduced on the exercise and all levels are repeated again.
Calf Raises 	Participant raises the heels until the body is on tiptoes to work the calf muscles and, at the same time, climbs the finger steps to reach the highest point possible.	Important for stability, posture and mobility as well as help the blood circulation.	Level 1 – Facing the bar, double leg heel raise, 2 hands Level 2 – Facing the bar, single leg heel raise, 2 hands Level 3 – Side on to the bar, double leg heel raise, 1 hand Level 4 – Side on to the bar, single leg (standing on outermost) heel raise, 1 hand Level 5 – Side on to the bar, single leg (standing on innermost) heel raise, 1 hand

Table 1 (Continued)

Bar – Hip Extension 	Participant, with control and keeping back and knee straight and foot flexed, slowly take leg backwards tightening bottom muscles.	Strengthens gluteal and hamstrings muscles and works balance.	Alternating legs, 5 on each: Level 1 – Comfortable speed Level 2 – Pulse twice at the top part of the movement. Alternating legs, 10 on each: Level 3 – Comfortable speed Level 4 – Pulse twice at the top part of the movement. Alternating legs, 15 on each: Level 5 – Comfortable speed Level 6 – Pulse twice at the top part of the movement.
Step-ups 	Participant steps up and down the platform.	Improves ability for using stairs and getting in and out the bath or bus.	Level 1 – Alternating legs, with hand support. Level 2 – Alternating legs, no hand support. Level 3 – 5 on each leg, with hand support. Level 4 – 5 on each leg, no hand support. Level 5 – 10 on each leg, no hand support. Level 6 – Sideways, 5 on each leg, no hand support. The 10cm high wooden block can be introduced before each level if participant reports a RPE greater than 7/10.
Bar – Hip Abduction 	Participant moves their leg to side with straight knee.	Strengthens hip stabilizer muscles and works balance.	Level 1 – Comfortable speed, 5 repetitions, alternate legs. Level 2 – Pulse twice at the top of the movement, 5 repetitions, alternate legs. Level 3 – Comfortable speed, 10 repetitions, alternate legs Level 4 – Pulse twice at the top part of the movement, 10 repetitions, alternate legs. Level 5 – Comfortable speed, 15 repetitions, alternate legs. Level 6 – Comfortable speed, 20 repetitions, alternate legs

*Wooden block dimensions: L 70cm x W 40cm x H 10cm.

Table 2: Balance exercises to be performed using the senior exercise park with their respective levels of progression.

Exercise	*Description*	*Functional Relevance*	*Progressions*
Gangway 	Participant walks backwards and forwards along the rickety bridge surface.	Helps to find a good stance for uneven and unstable surfaces like on the bus or underground.	Level 1 – 2 hands support, 1 foot per step. Level 2 – 1 hand support, 1 foot per step. Level 3 – no hand support, 1 foot per step.
Balance stool 	Balancing on an unstable stool.	Exercises the deep muscles that support the spine.	Level 1 – Pushing down edges of the stool, 2 hands on the bar. Level 2 – Pushing down edges of the stool, 1 hand support. Level 3 – Pushing down edges of the stool, no hand support. Level 4 – Pushing down edges of the stool, hands overhead. Level 5 – Pushing down edges of the stool, alternating hands overhead.
Balance Beam 	Participant walks back and forth along the beam.	Improves walking safely on awkward surfaces such as natural and unpaved paths. Walking on an undulating balance beam is a good balancing exercise.	Level 1 – 1 hand for support, normal walking. Level 2 – Heel to toe walking, hand support. Level 3 – Heel to toe walking, no hand support. Level 4 – Walking on toes with hand support. Level 5 – Walking on toes with no hand support. Level 4 – Normal walking with semi-squat, hand support. Level 5 - Normal walking with semi-squat, no hand support. Level 6 – Cognitive dual-task counting down by 2 and no hand support.
Ramp + Net   **Walking Through**   **Walking on the ropes** 	Participant walks up the ramp and steps down either through the net or on to the ropes, climbs through under the bar and walks back on heels and toes to the ramp.	Strengthens and exercises the lower limbs as well as exercises balance and flexes the ankles. Improves spatial awareness and coordination. Improves balance.	Walking through the net without hitting the ropes: Level 1-3 – Narrow stance, ranging from 2 hand support, 1 hand support and no hand support Level 4-6 – Wide stance, ranging from 2 hand support, 1 hand support and no hand support Walking balancing on the ropes: Level 7-9 – Narrow stance, ranging from 2 hand support, 1 hand support and no hand support Level 10 – On crosses of netting, no hand support Level 11-13 – Wide stance, ranging from 2 hand support, 1 hand support and no hand support Participant alternates the way he/she comes up the ramp by walking on toes or on heels. After reaching level 13, participant can come back to the ramp doing lunges. If ramp is too high for participant to come down before walking through the net, a wooden block (L 70cm x W 40cm x H 10cm) can be introduced until participants improves level of conditioning, strength and balance.

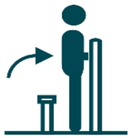
Table 3: Coordination exercises to be performed using the senior exercise park with their respective levels of progression.

Exercise	*Description*	*Functional Relevance*	*Progressions*
Taps on Platform 	Participant taps on the platform with feet.	Improves ability for using stairs and getting in and out the bath or bus.	Level 1 – Taps on the platform, alternating legs, hand support Level 2 – Taps on the platform, alternating legs, arms in front of the body. Level 3 – Taps on the platform, alternating legs, arms above head. Being the platform too high for participant to tap, a wooden block (L 70cm x W 40cm x H 10cm) can be introduced until participants improves level of conditioning, flexibility, strength and balance.

Table 4: Flexibility and mobility exercises to be performed using the senior exercise park with their respective levels of progression.

Exercise	*Description*	*Functional Relevance*	*Progressions*
Rounded Snake Pipe 	Participant moves the ring from one end to the other without touching the bar.	Strengthens and mobilises the shoulders. Improves hand–eye coordination and concentration skills. Helps getting dressed, combing hair, washing oneself, hanging up clothes.	Level 1 – Side facing, walking, and looking forward. Level 2 – Side facing, walking on heels and toes, looking forward.
Sharp Snake Pipe 	Participant stands on mark and moves the ring from one end to the other without touching the bar.	Strengthens and mobilises the shoulders. Improves hand–eye coordination and concentration skills. Helps getting dressed, combing hair, washing oneself, hanging up clothes.	Facing the snake pipe: Level 1 – Feet together, change hands in the middle. Level 2 – Feet together, same hand reaching across the body Side on to the snake pipe: Level 3 – Feet together, reaching forward, 5 each side. Level 4 – Feet together, reaching forward and backward, 5 each side. Level 5 – Feet together, reaching forward and backward, one side per set. Level 6-7 – Standing on one leg (outermost), ranging from 5 repetitions to 10 repetitions on each side. Level 8 – Standing on one leg (outermost), one side per set Level 9-10 – Standing on one leg (innermost), ranging from 5 repetitions to 10 repetitions on each side. Level 11 – Standing on one leg (innermost), one side per set.

Table 5: Functional exercises to be performed using the senior exercise park with their respective levels of progression.

Exercise	***Description***	***Functional Relevance***	***Progressions***
Screw and Turner 	Participant turns the screw and turner each direction whilst standing on one leg.	Improves daily activities such as opening doors and taps. Helps with opening doors and jars.	Level 1-3 - Single leg stance (SLS), ranging from 5, 10 and 15 repetitions each direction, so alternate legs. Level 4 – SLS, 15 repetitions each direction. Same leg for the whole set. Level 5 – SLS, 20 repetitions each direction. Same leg for the whole set.
Sit to Stand 	Participant sits and stands up from the seat or stands to squat and touch the bench.	Strength of muscles on lower limb and balance.	Not using the 10cm high block*: Level 1 – Sit to stand (STS) with hand support Level 2 – STS with arms in front of the body. Level 3 – STS with arms crossed on the chest. Using the 10cm high Block*: Level 4 – STS with hand support. Level 5 – STS with arms in front of the body. Level 6 – STS with arms crossed on the chest. Level 7 – Squatting to touch the bench, arms in front of the body. Level 8 – Squatting to touch the bench, bench arms crossed on the chest. Not using the 10cm high block*: Level 9 – STS pushing off with 1 leg mostly and lifting heel, alternating legs. Level 10 – STS pushing off with 1 leg mostly and lifting foot from the floor, alternating legs, with hand support. Level 11 – STS pushing off with 1 leg mostly and lifting foot from the floor, alternating legs, arms crossed on the chest. Level 12 – Sit to stand pushing off with 1 leg mostly and lifting foot from the floor, 5 on each, arms crossed on the chest. Add the 10cm high block*, participants repeats the same progression from level 10 to level 12.

*Wooden block dimensions: L 70cm x W 40cm x H 10cm.

Table 5 (Continued)

Stairs 	Participant steps up and down the steps. The handrail makes the exercise safe. Steps can also be used for stretching exercises.	Strengthens the heart and lower limbs.	Level 1-3 – stepping up and down slowly ranging from 2 hands for support, 1 hand for support and no hand support. Level 4-6 - stepping up every second step ranging from 2 hands for support, 1 hand for support and no hand support.

Abbreviation: STS= sit to stand

Table 6: Exercise stations.

Station Number	***Exercise 1***	***Exercise 2***
1	Push-ups	Taps on Platform
2	Modified Pull-ups	Gangway
3	Balance Stool	Calf Raises + Finger Steps
4	Sit to Stand	Round Snake Pipe
5	Ramp + Net + Climb Through	Sharp Snake Pipe
6	Balance Beam	Hip extension
7	Steps	Screws / Turners
8	Step-ups	Hip Abduction

Table 7: Order of progression and introduction of new exercises for the 18 weeks of intervention.

Week Number	***Exercise 1***
1 and 2	Stations 1 to 5
3 and 4	Stations 1 to 6
5 and 6	Stations 1 to 7
7-18	Stations 1 to 8

Table 8: Set time and rest for exercise progression for the 18 weeks of intervention.

Week Number	***Set Time***	***Rest Time***
1 to 2	60 seconds	60 seconds to change over and rest
3 to 8	60 seconds	30 seconds change over and rest
9 to 14	75 seconds	30 seconds change over and rest
15 to 18	90 seconds	30 seconds change over and rest

3.2.12 Fidelity Monitoring

To assure that the core elements that contribute to the success of intervention studies will be correctly documented and can be successfully translated into community settings, a number of process measures will be used to document, track and enhance the fidelity of this project. Firstly, all exercise supervisors will receive a written exercise protocol manual to be followed in all sessions. Secondly, participants will have their attended sessions recorded by the supervising researcher to make sure that they are receiving nearly the same amount of exercise prescription at the end of the 18 weeks of exercise intervention. Participants who have missed more than eight sessions (for being unwell or away) at the end of the 18-week period will be asked to make up these missed sessions until they reach a minimum of 35 hours (out of 50 expected hours) of exercise delivery. Finally, fidelity to treatment delivery will be monitored via the use of exercise cards (per participant) for the specific training date with further details of the participant’s performance and general suggestions for the next session (i.e. improve level of certain exercise, monitor pain, watch technique, etc.).

3.2.13 Sample size

Power analysis was undertaken using previously published discharge data on the primary outcome measure - the BOOMER balance measure [158], and assuming an improvement of 3 points (reported as the minimum detectable difference [158]) and an effect size of 0.5. A sample size of 48 participants per group will be required for a power of 0.80 and alpha of 0.05. We will allow for 20% dropout rate (this is a conservative estimate based on previous exercise programs with older people), and therefore will recruit 60 participants per group.

3.2.14 Data Management and Statistical Analysis

All analyses will be conducted on an intention-to-treat basis. If there are chance imbalances in baseline participants' characteristics, then these variables will be used as covariates. Mixed linear modelling incorporating intervention and control groups at the baseline and two follow up time points (18 weeks and 26 weeks after intervention commencement), with the number of sessions attended and baseline physical activity level as covariates, will be carried out using SPSS. Comparisons will be made for the primary outcome (BOOMER) and secondary outcomes (functional tasks, strength measures, gait parameters, health related quality of life measures, and psychosocial measures). Although the number of falls is being recorded over a period of 12 months after the commencement of participants, this study is not powered for falls outcomes. Regarding the qualitative data being collected, the interviews from EPIG participants will be analysed using a thematic analysis approach [186], as described above.

3.3 Discussion

In this community based study we aim to evaluate the effectiveness of an exercise intervention using an exercise park specifically designed for older people in reducing the risk of falls and improving strength and balance. Whether such exercise parks have an impact on reducing the risk of falls, improving muscle strength and balance and quality-of-life is not yet known. As such this planned trial will be the first to provide evidence if the exercise park can improve physical health or psychological well-being. In addition, this study aims to describe this innovative exercise approach, and report its feasibility and the challenges associated with running this in a community setting.

Falls and related injuries are the leading cause of disability among older adults [76]. Physical activity, more specifically exercise, has been shown to be effective in preventing falls in older people [146]. However, data from the 2011–12 Australian Health Survey: Physical Activity report found that only 36.6% of males and 38.8% of females over 65 engage in sufficient physical activity [189]. Considering the 75 and over group, these figures are even more problematic with just one in three men and one in five women being sufficiently physically active [189]. Thus, finding falls prevention initiatives that increase levels of physical activity and factors that contribute to adherence such as the exercise park initiative is important to reduce their risk of falling and their rate of falls.

Exercise parks may offer a playful and enjoyable experience to their users which may increase compliance for participation in fall prevention programs. By providing a fun but physically challenging environment, this novel and unique concept may provide an alternative strategy to enhance physical activity levels in older individuals and consequently increase their health and ability to cope more effectively with the challenges faced in their daily life. Subscribing to this idea, a recent study recommended that physical activity sessions that focus on overall movement rather than structured exercise program might be more achievable for the older population group [133].

Community-based exercise programs that focus on health and wellness for physically inactive community-dwelling seniors have been shown to be effective in reducing feelings of loneliness and social isolation [190]. After people retire, they are more likely to stay at home alone, watching television and reading newspapers, and consequently become sedentary in their lifestyle [191, 192]. The senior exercise parks may provide an opportunity for seniors to socialize more, improve their quality of life and, their physical and mental health. This novel method could be an option for them to exercise their bodies and minds in an enjoyable way through strength, balance and coordination exercises as well as simple activities to support a variety of activities of daily living.

The type of environment on which exercise-based therapeutic interventions are offered is vital for their success [133]. A study with post-menopausal women showed that indoor activities have been associated with negative feelings such as frustration, anger, sadness and anxiety whereas outdoor programs have been associated with positive feelings such as happiness, joy and pleasure [193]. Contributing to these findings, outdoor exercises were shown to improve mood and self-esteem in older people, and seniors tend to attend more to the outdoor sessions compared to the indoor ones [133]. However, outdoor sessions such as the one proposed by the senior exercise park program can be dependent on climate and seasonal conditions which has the potential to influence adherence [194]. The planned project will explore how participation can be affected by seasonal conditions.

The proposed intervention will use task-specific exercises (e.g. step and stair climbing, walking on unstable and uneven surfaces, etc.) which can be easily translated to older adults' activities of daily living. In addition, senior exercise parks can be installed outdoors or indoors in public places such as community centres and parks free of charge to the public. While an intervention of this nature might comprise some financial and logistic engagement of the local councils and community organizations, this initiative could potentially be a cost-effective way to engage older individuals in a more active and healthier lifestyle.

This study is evaluating not only quantitative data but also qualitative data through EPIG participant interviews. Therefore, more comprehensive information to assess the acceptability, likely barriers, facilitators to adherence and general experiences of this targeted group throughout participation in the project can be obtained and that may help in the analysis of the feasibility of the proposed exercise intervention [195].

It has been demonstrated that older people of lower socio-economic status have a higher rate of hospitalisation due to falls [33]. Specifically in Melbourne, the western and northern suburbs of Melbourne comprise one of the areas of lowest income and more socioeconomic disadvantage [34]. Therefore, this would be an important area to target future interventions to prevent falls in older populations and one of the reasons why the exercise park used in this project is installed in Sunshine North, a western suburb of Melbourne. However, the western side of Melbourne is also marked by the existence of many multicultural groups and ethnicities (high non-English speaking immigrants) which can potentially make recruitment and retention of participants more complicated due to cultural and language barriers. Low literacy levels, competing responsibilities and location of the testing site and intervention have been listed as reasons why recruitment in these areas of lower socio-economic status may face challenges [196]. Thus, the outcomes of this study will examine how these mentioned factors play a role and may affect the feasibility of this kind of initiative in these areas.

Community based falls prevention interventions supported by community organizations are important as they have the potential to be sustained. Our focus will be on the benefits to the individual and the opportunities to continue such a program beyond the duration of the project. In addition, this project will provide policy makers with empirical evidence of the effectiveness of an exercise park and the factors which might influence the implementation of such parks on a larger scale.

3.4 Limitations

This study has a number of limitations. Firstly, it has been reported that some participants who do not receive their preferred treatment may experience “resentful demoralisation" [151], may not comply with the program structure proposed, may not report accurate responses on the follow-up appointments and may even drop out from the trial [197]. This may introduce some bias which could possibly affect the internal validity of the trial. However, because their preference is being recorded before the randomization occurs, this preference will be taken into account when analysing and interpreting the results. Secondly, due to budget limitations, this study will not be blinded where the principal researcher will be conducting the assessments, the randomization and the exercise intervention. However, despite these limitations, the results of this study will be able to provide an insight on how older adults will respond to this novel and unique senior exercise park. Furthermore, this study will report the possible health benefits and well-being improvements on older people when using this exercise park and will guide further larger research trials.

3.5 Conclusions

The outcomes of this project will provide empirical evidence for the effectiveness of the use of the novel exercise park in the community and how its use can improve physical (e.g. strength and balance), psychological (e.g. fear or falling and self-perception) as well as psychosocial (e.g. increased social participation) aspects of older people. In addition, this study will explore the barriers to participation and the acceptability and feasibility of the senior exercise park in the Australian older community as a mode of physical activity in older age.

Chapter 4 – Feasibility and Effectiveness of the Senior Exercise Park Intervention - Quantitative Results

Statement of contribution to co-authored published paper:

This chapter includes a co-authored published paper (as published in the journal) and will present the quantitative results of the investigation of the feasibility and effectiveness of the senior exercise park program. The bibliographic details of this co-authored paper including all authors involved are:

Sales, MP, Polman, R, Hill, KD & Levinger, P, *A Novel Exercise Initiative for Seniors to Improve Balance and Physical Function.* Journal of Aging and Health. 2016. doi: 10.1177/0898264316662359

My contributions to this paper involved the data analysis, designing, writing and preparation of the draft as well as the final version of this document. I responded to the comments raised during peer review process and made final amendments prior to publication.

21 Apr 2017

Myrla Sales

21 Apr 2017

Principal Supervisor: Associate Professor Pazit Levinger

4.1 Introduction

Preventing falls, improving muscle strength, balance and physical function among older adults are key public health priorities. Falls are significantly associated with reduction in quality of life of older adults as well as functional decline [23], with 30-35% of older people living in the community and aged over 65 years falling at least once a year [23]. After having a fall or being fearful of falling, older people tend to develop depression, anxiety, reduce social contact, decrease activity and mobility, increase use of medications and lose independence and autonomy in their lives [70]. These factors may also be responsible for affecting daily functioning in older adults by promoting further reductions in muscle strength, balance and gait speed [71]

Randomized controlled trials focusing on reducing the risk factors of falls, falls prevention and improvement of muscle strength, balance and mobility in older adults have shown that exercise interventions slow down functional losses expected with increased age [79]. Consequently, exercise interventions are able to improve quality of life and maintain functional independence in older adults [79]. However, participation in these exercise or falls prevention interventions are rather low [70], suggesting that older people may be reluctant to participate, or do not feel that interventions are sufficiently appealing or beneficial for them to take part in.

In order to increase exercise participation and adherence for older adults in a community setting, a unique purpose-built outdoor exercise park was designed to provide a fun but still physically challenging environment for older adults (https://www.youtube.com/watch?v=lO6jz_w5vcg&feature=youtube). With this novel concept, older adults might feel more inclined to exercise and to adopt a healthier lifestyle given that these playful and purposeful activities are also functional and practical to what they do in their daily living activities [141]. Furthermore, older adults tend to partake in initiatives that can help them to maintain independence, autonomy and confidence, and, consequently promoting a more positive self-identity [142]. The social interaction and support associated with this type of exercise park could make the sessions more enjoyable given that older adults show preference to exercise in groups [198]. Moreover, exercising outdoors has been shown to contribute to significant improvements in mood, self-esteem and reduce levels of depression among older adults [133]. Therefore, the aims of this study were to investigate the feasibility, and short-term effectiveness of an exercise intervention using a novel outdoor exercise park designed for seniors in improving their balance, physical function and quality of life.

4.2 Methods and Design

The full description of this study's methods, design, randomization process, exercises and tests performed can be found on the full trial protocol previously published [199].

4.2.1 Design

This study was a parallel randomised controlled trial with pre and post intervention design (outcome assessments at baseline and at 18 weeks after participation commencement, and number of falls measured over a 12-month period from enrolment in this study) comparing two groups: an exercise park intervention program for older people and a control group.

4.2.2 Participants

One hundred twenty community-dwelling people aged between 60 and 90 years old were sought via community health promotion events and advertisement in local newspapers, magazines and online social networking media. Participants were also from diverse settings such as local senior organizations, retirement villages, community centres, senior clubs and associations in Melbourne.

4.2.3 Inclusion and Exclusion Criteria

Participants were sought via community health promotion events and advertisement in local newspapers, magazines and online social networking media. Participants were also from diverse settings such as local senior organizations, retirement villages, community centres, senior clubs and associations in Melbourne. Thus, older adults who had one or more falls in the previous 12 months or who were concerned about having a fall were recruited for this study. Participants who were generally active and independent in the community with no more than a single point stick used for regular outdoors walking (at least three times per week) were included. More details about inclusion and exclusion criteria are detailed on the study protocol [199].

4.2.4 Randomization

Participants were randomly allocated to one of the following groups: (1) Exercise Park Intervention Group (EPIG) or (2) Control Group (CG). Assessors and participants were not blind to their respective group allocation (EPIG or CG). Block randomization stratification by gender using opaque envelopes was undertaken, so that blocks of 12 participants (6 for intervention group and 6 for control group) were randomized at a time. To accommodate couples (e.g. partners/married couples) participation, randomisation by couple also took place.

Participants from the EPIG underwent an 18-week exercise intervention with no cost to the participants. Participants in the CG were advised to continue with their usual daily activities and met the research team every two weeks to take part in some social activities (nine meetings of two-hour duration over 18 weeks of participation).

4.2.5 Treatment/Group Preference

Each participant's group preference was documented (i.e. as control group, exercise intervention group or no preference) to identify if differences exist between those who received their preferred allocation and those who did not.

4.2.6 Study Protocol

All participants were fully informed about the nature of the study and signed a consent form. This study was approved by the Human Research Ethics Committee of Victoria University, Melbourne (Application ID. HRE13-215). The study was designed according to the Consolidated Standard of Reporting Trials (CONSORT) guidelines and publications associated with the trial were reported according the CONSORT 2010 Statement [148, 149].

4.2.7 Outcome Measures

Sociodemographic factors (such as age and gender), medical conditions, medications currently prescribed, past history of surgeries and medical procedures, smoking habits as well as alcohol consumption were obtained via a structured questionnaire. Anthropometry measures including body weight and height were measured using digital scales and a stadiometer respectively, and body mass index was calculated (weight (kg) / height (m^2)).

4.2.7.1 Primary outcome: The Balance Outcome Measure for Elder Rehabilitation (BOOMER)

The BOOMER battery test was used as the primary outcome to assess the effectiveness of the novel purpose-built exercise park in improving balance. This test is a multi-item balance measure, which comprises four well validated clinical measures (step test [153], timed up and go (TUG) [154], functional reach (FRT) [155], and static standing balance [156]) [158].

4.2.7.2 Secondary Measures – Strength and Physical Function

The following secondary measures were used to assess balance, muscle strength, mobility and physical function in older adults. The single leg stance test standing on the dominant leg with eyes open was used to measure static balance [200]. The average hand grip strength of both hands using a TTM digital hand dynamometer (Mentone Educational Centre, Melbourne, VIC) [163] was taken to measure physical strength. The two-minute walk test was used to assess exercise tolerance [166] and functional mobility [167].

Lower limb strength was assessed via the 30-second sit-to-stand test [169] and measurement of the strength of the knee extensor muscles using a purposely built force transducer [49]. Finally, the assessment of gait speed was performed with the use of the GaitRite® system (CIR System, Inc, Harverton PA) instrumented walkway system.

4.2.7.3 Secondary Measures – Feasibility

Feasibility was defined as the number of participants recruited and retained over the recruitment period, overall adherence and seasonal adherence, safety and adverse effects. Overall adherence to the exercise program was defined by the number of sessions attended: 100% adherence if an EPIG participant attended 35 sessions. EPIG participants' participation and attendance was recorded via a spreadsheet diary and was collected respectively by the exercise supervisor of that participant on each specific session or by the principal researcher.

Seasonal adherence was recorded as adherence over Summer (December to end of February), Fall (March to end of May), Winter (June to end of August) and Spring (September to end of November). Also, the number of sessions that were cancelled due to rainy, windy and excessively hot days (above 37°C) were recorded given that these conditions potentially put participant’s safety and health at risk. Safety and adverse effects were measured by the number of falls incidents during exercise sessions and muscle/joint injuries or strains reported after undertaking the exercise session.

4.2.7.4 Secondary Outcomes – Health Related Quality of Life and Psychological Measures

The Short Form (12) Health Survey Version 2 (SF-12v2™) was used to evaluate the individual health status [176]. Physical and Mental Health Composite Scores (PCS & MCS) were computed using the scores of twelve questions and range from 0 to 100, where a zero score indicates the lowest level of health measured by the scales and 100 indicates the highest level of health [176].

The Short Falls Efficacy Scale International (Short FES-I) questionnaire was used to record fear of falling [201]. The total score ranges from 7 (not concerned) to 28 (severe concern) where higher scores are associated to a greater fear of falling [201].

4.2.7.5 Secondary Measures – Physical activity and number of falls over 12 months

Physical activity calendars were used to monitor if EPIG or CG participants have participated in any other physical activities during their participation in the study and to monitor if the participants had falls over the 12 months from commencing involvement in the project. Calendars were returned using pre-paid envelopes and participants were followed up with a phone call in the cases their calendars were not returned within two weeks of the end of each month.

4.2.8 The Exercise Park Intervention Program

The senior exercise park used in this project was provided in-kind by Lappset (Lappset Group Ltd., Rovaniemi, Finland) (Fig. 1) and was installed at St Bernadette's Community Respite House in Sunshine North, Victoria, Australia. The exercise park consists of a number of components and stations that aim to work on the following aspects of physical performance: Upper body mobility and fine motor skills, balance and coordination, lower limb and upper limb strength, stretching and flexibility (as detailed on this study protocol [199]). The exercise sessions were provided two times a week (each class approximately 1 to 1.5 hours duration) and were supervised by an accredited exercise physiologist. Each session consisted of 5-10 minutes of warm-up exercises, followed by 45-75 minutes on the equipment stations, and concluded with 5-10 minutes of cool down exercises. The exercise classes contained a maximum of six participants and were circuit based with the warm up and cool down exercises being performed in a group and the core part of the session being carried out in training pairs. Exercisers were paired in stations and an exercise session could include up to eight stations (Table 6).

4.2.9 Data Management and Statistical Analysis

Power analysis was undertaken using previously published discharge data on the primary outcome measure - the BOOMER measure [158], and assuming an improvement of 3 points (reported as the minimum detectable difference [158]) and an effect size of 0.5. A sample size of 48 participants per group would be required for a power of 0.80 and alpha of 0.05. A 20% dropout rate was anticipated based on previous exercise programs with older people. Therefore, this study aimed to recruit 60 participants per group.

All analyses were completed using SPSS version 22.0 and a p value less than 0.05 was considered statistically significant. Effect size (η_p^2) from SPSS was used to determine effect size as follows: η_p^2 value greater than 0.14 was considered a large and significant effect size whereas 0.01 and 0.06 were considered small and medium, respectively [202]. For the primary outcome, the BOOMER test, repeated measures ANCOVA univariate analysis was performed to examine the difference between groups (baseline vs 18-week assessment) and between groups over time (group by time interaction) whilst controlling for age. Repeated measures ANCOVA were performed to evaluate the differences between groups (baseline vs 18-week assessment) and between groups over time on the individual components of BOOMER test, on the secondary physiological and quality of life and psychological outcomes. Ninety-five percent Confidence Interval (95% CI) was calculated for the differences between the two groups over time. Age was included as a covariate given the decline of many physiological functions which happen with increasing age [203]. Prior to the conduct of the main analysis, data were grouped based on group preference (preferred and non-preferred group) and analysed to identify any possible effect of group allocation preference on the outcomes.

A mixed modelling analysis and the associated intention-to-treat approach were not used in the present study due to the following reasons: (1) for some participants, only one data point was available beyond baseline due to missing data (drop out) and (2) a disproportionately high number of participant dropouts from the control group as a result of not being allocated to the exercise intervention group. Furthermore, there is no adequate recommendation for replacement of missing values greater than 20% [204] and imputation of values for the missing data in similar cases to this study (dropout > 10%) is likely to produce biased estimates of treatment effect [205]. Therefore, a "per protocol" approach has been used in the analysis of the data. By using per protocol analysis, the risk of having the treatment effect underestimated or overestimated due to missing data is reduced [206] which will allow a more accurate representation of the actual effectiveness of the present exercise intervention [207]. Similarly, only the data of participants assigned to the exercise intervention who actually received, complied with, and completed the treatment have been used [207]. As it has been previously showed that older adults need to attend exercise programs at least once weekly to achieve muscle strength gains and improve neuromuscular performance [208], participants from EPIG who did not comply with the exercise intervention and failed to attend at least one session per week (i.e. total attendance less than 50%) were excluded from the statistical analysis.

4.3 Results

Sixty-two older people (mean age of 71.4 ± 6.7 years; 44 females; 18 males) living in the community volunteered to be part in the study. Challenges with recruitment meant that this final sample of sixty-two older people was lower than planned. More than 60% of participants of both groups had a history of at least one fall in the last 12 months. The mean age of participants in both groups was 70 years ± 6 and 72.9 years ± 6.1 for CG and EPIG, respectively with the majority of participants being females (81% and 63% in CG and EPIG, respectively). Participants' characteristics are provided in Table 9. No significant differences were observed at baseline between the two groups. Seventy percent of the total dropout from the control group was due to participants not being allocated to the EPIG, further details about dropout and exclusion are provided in Fig. 3. Table 10 provides information about the primary and secondary outcome measures.

4.3.1 Treatment/Group Preference

Ninety-six percent (n=26) and 43% of participants from the intervention and control group, respectively, received their group preference. The difference between pre and post values for all outcome measures (delta change) based on participant preference was calculated and compared. As only one participant from the intervention received their non-preferred group allocation, analysis was conducted only for the control group. Multivariate analysis showed no differences between preferred and non-preferred group allocation ($p>0.05$).

Table 9: General characteristics of the participants of this study evaluating the quantitative results

Characteristic	***Control Group (n=21)***	***Exercise Intervention Group (n=27)***
Age (Years)	70±6	72.9±6.1
Gender (Females, n (%))	17 (81)	17 (63)
BMI (kg/m^2)	28.1±5.0	28.9±5.3
Current Smoker (n (%))	2 (9)	1 (3)
Ex-Smoker (n (%))	6 (29)	10 (37)
Daily Alcohol Consumption (n (%))	11 (52)	11 (41)
Average Number of Medications	3	3
Previous Falls History (>=1fall, n (%))	13 (61.9)	17 (62.9)
Follow-up Falls Over 12 months (n (%))	10 (47.6)	11 (40.7)

4.3.2 The exercise program

All participants allocated to EPIG program performed all exercises as per description on the study protocol [199] with minimal adjustment based on individual abilities. All participants were able to perform all exercises as per the study protocol.

These exercises were paired up in exercise stations as shown on Table 6. Additionally, an average of 35 sessions were run for each group of participants with the objective of reaching 50 hours of cumulative exercise previously suggested to be effective in reduction of falls risks for older adults [57].

4.3.3 Primary outcome: BOOMER Test

No significant difference was found between the groups at baseline and after 18-week participation for the BOOMER test or the BOOMER individual components ($p>0.05$). No significant differences were found for the BOOMER test between the groups over time ($p = 0.46$, 95%CI -.354 to .830) (Table 10). The component tests of BOOMER test were also analysed individually and no significant differences were observed between the groups over time ($p>0.05$).

4.3.4 Secondary Outcomes – Strength and Physical Function

Participants from EPIG showed significant improvement on single leg stance ($p = 0.02$, 95%CI -8.35 to -.549), knee strength ($p < 0.01$, -29.14 to -5.86), two-minute walk ($p = 0.02$, -19.13 to -.859) and timed sit to stand ($p = 0.03$, -2.26 to -.143) tests following the 18-week intervention compared to the CG (Table 10). A significant difference was found between the groups only for the hand grip strength when comparing baseline values from each group ($p = 0.01$, Table 10). Univariate t-test revealed greater strength for the EPIG at the follow up assessment ($p = 0.04$, 95%CI -10.39 to -0.11).

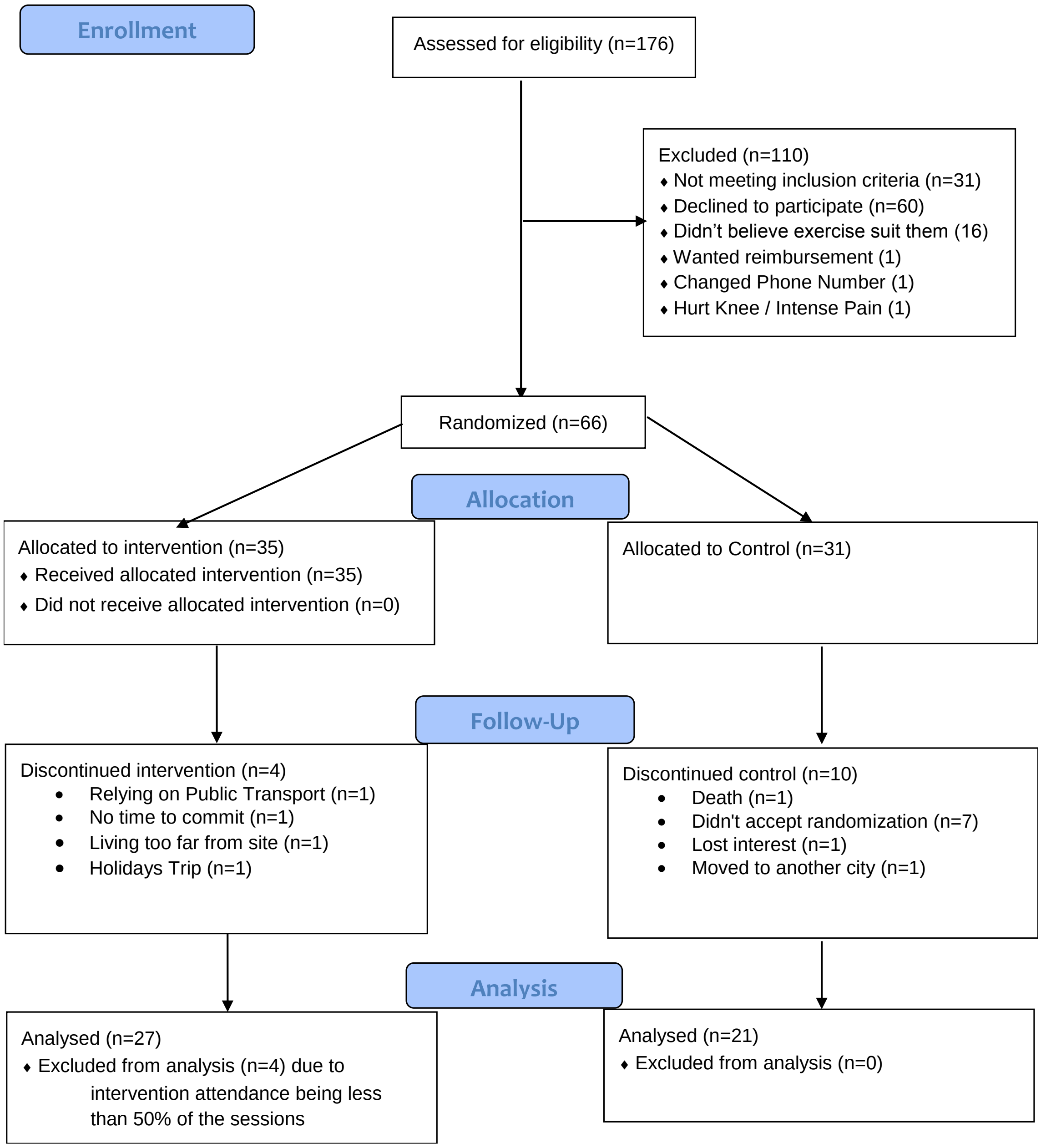


Fig. 3: Consort Flow Diagram of Recruitment and Randomization – Results

Table 10: Primary and secondary outcome measures before and after the 18-week participation for the CG and EPIG (values are mean ± SD)

Measure	*CG (n=21)*		*EPIG (n=27)*		*P value Group by Time Interaction (95% CI)*	η_p^2	*p value between groups*
	Pre	*Post*	*Pre*	*Post*			
BOOMER - Total Score (Out of 16)	*13.5±1.7*	*13.9±1.4*	*13.6±1.4*	*13.7±1.3*	*0.6 (-.354 to .830)*	*0.00*	*0.4*
Physical Measures							
Single Leg Stance (sec)	18.7±*11.1*	16.0±*9.2*	15.6±*11.0*	17.3±*11.3*	p<0.01* *(-8.35 to -.549)*	0.11ǂ	0.4
Knee Strength (N.m)	83.7±*33.1*	78.5±*33.8*	84.2±*36.5*	96.4±*44.4*	p<0.01* *(-29.1 to -5.86)*	0.15ᶲ	0.1
Hand Grip Strength (Kg)	20.6±*7.2*	20.9±*7.1*	26.3±*10.6*	26.5±*9.6*	0.4 *(-1.52 to 1.88)*	0.02†	0.01**
Two Minute Walk (m)	149.0±*29.5*	150.4±*22.5*	140.6±*30.5*	152.1±*28.7*	p<0.01* *(-19.1 to -.859)*	0.12ǂ	0.7
Timed Up and Go Fast (sec)	7.0±*2.0*	7.0±*1.4*	7.4±*1.8*	7.1±*1.4*	0.6 *(-.315 to .913)*	0.01†	0.8
Sit to Stand (reps)	11.0±*2.2*	11.5±*2.5*	10.5±*3.0*	12.1±*2.7*	p<0.01* *(-2.26 to -.143)*	0.10ǂ	0.6
Gait Speed (m/s)	1.34± *0.20*	1.36.5±*0.16*	1.31±*0.19*	1.33±*0.17*	0.8 *(-6.11 to 4.30)*	0.00	0.8
Fear of Falling and Quality of Life							
Short FES-I	11.3±*4.0*	10.9±*3.7*	10.3±*3.4*	9.3±*2.5*	0.4 *(-1.10 to 2.05)*	0.02†	0.1
SF12 PCS	49.1±*7.91*	48.9±*7.6*	46.9±*7.56*	49.6±*8.29*	0.2 *(-7.24 to 1.37)*	0.03†	0.8
SF12 MCS	51.4±*6.1*	51.6±*7.9*	53.1±*9.8*	54.5±*7.0*	0.6 *(-5.76 to 3.22)*	0.01	0.4

* Significant at p < 0.05 for group by time interaction. ** Significant between groups at the follow up assessment. † Small effect size. ǂ Medium Effect Size. ᶲ Large Effect Size. BOOMER: Balance Outcome Measure for Elder Rehabilitation. FES-I: Falls Efficacy Scale International. SF12-PCS and SF12-MCS: Physical and Mental Component scores of the Short Form (12) Health Survey (SF-12), respectively.

4.3.5 Secondary Outcomes - Feasibility

Twenty-seven participants from EPIG completed the 18-week intervention (87%) with mean attendance of 79.6%. However, only 14% of participants in the control group attended to the social meetings offered. Eighty-six per cent of control group participants who did not attend the social meetings (n = 18, M age = 70 years ± 7.3) reported they would come back for the follow-up assessments. However, due to the distance between their houses and the venue where the social meeting sessions were being offered (i.e., Maidstone Community Centre), they informed that they would not be interested in attending to the social meetings. These control group participants were living approximately 19.2km away from the community centre and, when contacted about the social meetings, they reported that the distance to be travelled only to have a social meeting was not worth it. Summer and autumn were the seasons that demonstrated the highest levels of attendance with participants respectively attending 86.1% and 72.7% (Fig. 4). Two falls during exercise sessions were reported with two participants. One participant missed the seat during the sit-to-stand exercise and the other lost balance when stepping down from a platform. No injuries or adverse events were reported from these two episodes nor during the research trial. Only 9.6% of sessions had to be cancelled due to rain. Also, no participants in the exercise intervention group reported experiencing uncomfortable delayed muscle soreness or fatigue post-exercise that limited them from doing their daily tasks.

4.3.6 Secondary Outcomes – Fear of Falling and Quality of Life

No significant differences were found for fear of falling (Short FES-I, p = 0.4, 95%CI -1.10 to 2.05) and quality of life (SF-12 PCS and MCS respectively, p = 0.2, -7.24 to 1.37; p = 0.6, -5.76 to 3.22) between EPIG and CG over time.

4.3.7 Secondary Measures – Number of Falls Over 12 months

No significant difference was found for the number of falls between EPIG and CG after 12 months (p = 0.78); although there was a reduction of 35.2% in the number of fallers among EPIG participants (Table 9) and 23.1% among CG participants.

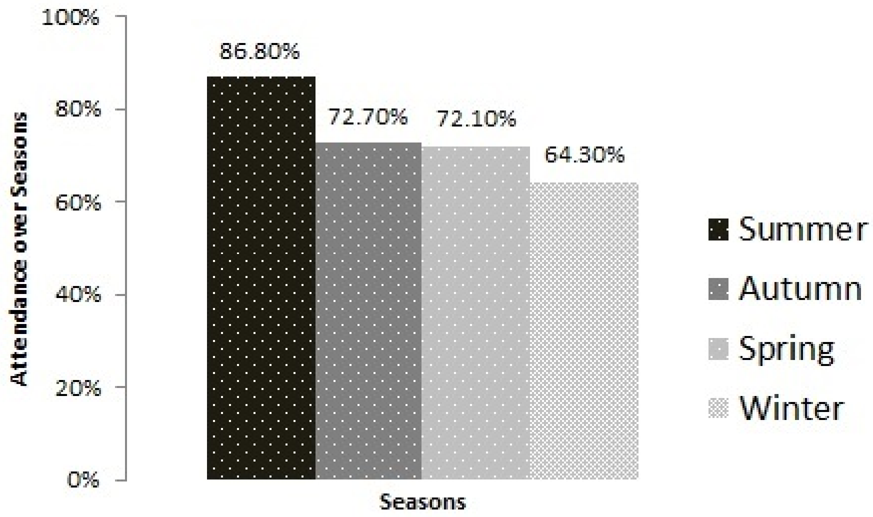


Fig. 4: Participant's Attendance over Seasons

4.4 Discussion

Participation in the 18-week exercise program using the purpose-built exercise park resulted in improvement in muscle strength, balance and physical function in older adults. Furthermore, given the relatively high attendance and retention rates observed among participants allocated to the exercise intervention group and the absence of major adverse events which could compromise the safety of participants, this novel concept might be a feasible option to improve participation and adherence to exercise programs aiming to reduce falls among older adults.

The importance of balance in preventing falls among older adults is well established [209]. As balance is multi-dimensional, the BOOMER, a test battery that incorporates a number of key domains of balance (static and dynamic balance, including measures of stepping, reaching and turning, that are commonly involved in falls) was used in this present study. Our results showed no significant improvements in the BOOMER test among participants from the intervention group across time. Participants of both groups, at baseline, nearly reached the maximum BOOMER score value of 16 (CG mean =13.4, EPIG mean = 13.5) and the same was observed when evaluating each component test individually suggesting that only minimal improvement can be achieved. Hence, the lack of improvement could be a reflection of a ceiling effect and that this chosen primary outcome measure may not be sensitive enough to be used on a sample of independent and mostly healthy community dwelling seniors. Previous research on the BOOMER has only used older adults in geriatric and rehabilitation units [157].

Exercise interventions targeting improvement in muscle strength, balance, mobility, agility, and functional tasks have been reported to be effective in reducing risk of falls and the number of falls among older adults [84]. In the present study, significant improvements in knee strength, balance (single leg stance), two-minute walk test and sit to stand were demonstrated following the eighteen-week exercise intervention with light to moderate but still challenging exercises. A non-significant reduction in the number of falls by 35.2% for the exercise intervention group was also reported, although this sample is underpowered for identifying a significant difference on this outcome. The ability to walk and function are important to reduce disability and promote independent living among older adults [210]. Similarly, muscle strength and balance have been reported to be critical elements responsible for maintaining physical function, mobility and vitality in old age [157]. Given the prescribed exercises were similar to daily tasks required in daily life, the functional and translational aspect of the exercises proposed might have contributed to the positive outcome on the physical and mobility measures which can positively affect confidence and self-efficacy [211]. Interventions which particularly target exercise self-efficacy, perceived exercise enjoyment, confidence and satisfaction are more prone to promote behavioural change in older adults [211]. A further investigation with a larger sample size is now needed to evaluate if using the senior exercise park would also result in reduction in the number of falls among older adults.

Despite the improvements in physical performance and function, no significant improvements in quality of life and falls efficacy were found between the groups of the present study. Participants from both groups were more independent and physically capable with relatively high baseline values for the quality of life measures compared to the reported Australian population aged 70+ (Table 10) [212]. Similarly, although presenting some concern about the possibility of having a fall or a history of fall, current participants of this study showed relatively low fear of falling (Table 10) when compared to the average value expected for older adults between 70-80 years [201]. Therefore, older people with lower levels of quality of life and with greater fear of falling might result in greater improvement in these domains when accessing the senior exercise park intervention, however this would require further investigation.

Although exercise has been shown to be an important and effective approach to preventing falls in older people [57], adherence to exercise programs remains a persistent problem [82]. In this present study, a high adherence rate of 87% and attendance rate of 79.6% was reported among participants in the exercise intervention group. The social context and support element of the EPIG program, which participants called “the get-together moment”, provided the sessions with a playful and relaxed atmosphere that probably camouflaged the physical challenge they were facing while exercising throughout different stations. Furthermore, offering physical sessions with high emphasis on social support (e.g., social support provided by exercise classmates and exercise team leader) is a key way to achieve success with the adherence and retention of older adults participating in exercise interventions [213]. The high attendance and adherence observed might also be related to the sessions being run outdoors despite the unpredictability of Melbourne's weather. Importantly, it has been shown that older adults tend to favour attending outdoor sessions over the indoor sessions [133] and that outdoor exercises greatly improve mood in older people [133].

Apart from the two minor fall episodes which happened during the exercise session delivery, no adverse events nor muscle strains or injuries that needed further medical intervention were reported during the trial. However, it is important to note that participants were working in pairs and had one exercise physiologist closely accompanying and supervising them throughout the entire session. To allow for broader public use of the exercise park, a simplification of the exercise protocol might be required so that older participants would be able to exercise more independently, but safely. Additionally, older adults could come and meet an allied health professional at a pre-established frequency (e.g. once a month) to proceed with establishing and progression of their exercise routine.

4.5 Limitations

While this study provides useful information about the effectiveness of an exercise intervention using an outdoor senior exercise park, several limitations are acknowledged. Firstly, we had an overall relatively modest sample size. The BOOMER test battery chosen as the primary outcome was not adequately sensitive to the population group studied. Furthermore, it is believed that the involvement, adherence and attendance to this project could have been higher if the senior exercise park had been installed in a location accessible by public transport and in a more central suburb of Melbourne. For future trials, location of the exercise park needs to be considered to allow easy access. Moreover, to facilitate the attrition of participants in a control group and to minimise dropout rate (as observed in this study), the control group should be offered some other non-physical activities which are perceived as meaningful for older people in combination with social activities rather than solely social activities.

4.6 Conclusions

The 18-week exercise program using a senior exercise park has been shown to be effective and safe in improving balance, muscle strength and physical function among older adults, and, therefore, may reduce the risk of falling in older people living in the community. This initiative demonstrated high adherence and participation rate. However, further investigation with a larger sample size is now needed to evaluate if the exercise park intervention would also be effective in reducing the number of falls among older adults.

Chapter 5 – Feasibility and Effectiveness of the Senior Exercise Park Intervention - Qualitative Results

Statement of contribution to co-authored published paper:

This chapter includes a co-authored paper which was accepted for publication in The International Journal of Aging and Society. This chapter will present the qualitative results of the investigation of the feasibility and effectiveness of the senior exercise park program. The bibliographic details of this co-authored paper including all authors involved are:

Sales, MP, Polman, R, Hill, KD & Levinger, P, *Older Adults' Perceptions to a Novel Outdoor Exercise Initiative: A Qualitative Analysis.* The International Journal of Aging and Society. 2018 (Press).

My contributions to this paper involved the data analysis, designing, writing and preparation of the draft as well as the final version of this document. I responded to the comments raised during peer review process and made final amendments prior to publication.

Myrla Sales 21 Apr 2017

Myrla Sales

21 Apr 2017

Principal Supervisor: Associate Professor Pazit Levinger

5.1 Introduction

There is a strong focus on healthy ageing in research and the benefits of exercise for older adults in order to prevent falls, improve muscle strength, balance and physical function [2]. Exercise interventions are well known for slowing down functional losses expected with increased age [79] and for improving quality of life and psychological well-being [79] as well as physical self-perceptions and self-esteem in older adults [214].

However, most older adults do not engage in regular physical activity or exercise [11]. The benefits of an exercise intervention depend on continued adherence and attendance rates to these interventions. It is estimated that half of the older adults who begin a physical activity/exercise program in community settings drop out within the first twelve months [215]. Furthermore, uptake rates (i.e., participation) for exercise interventions in the community are typically less than 50 per cent [216] and it can often be as low as 10 per cent [217].

Less than half of older adults take part in complimentary falls-prevention interventions in the community [102]. Older adults' barriers to participation in exercise interventions, primarily falls prevention interventions, include denial of falling risk, the belief that no additional falls prevention measures were necessary, practical barriers to attendance at groups (e.g., transport, effort, and cost), and a dislike of group activities [70]. Moreover, lack of motivation, illness/disability, lack of leisure time or lack of financial resources were also reported as barriers to exercise participation [104].

It has also been suggested that older people may be reluctant to participate, or do not feel that existent interventions are sufficiently appealing or beneficial for them to take part in [70]. Older adults are more likely to maintain their exercise participation in activities that focus on the enjoyment of exercise participation than in activities that rely primarily on extrinsic motivation such as the expectation of improved health and well-being or reduction of the risk of falls and number of falls [109]. Consequently, a novel exercise intervention that incorporates social interaction and enjoyment in addition to the well-known physical and psychological benefits may improve uptake, engagement and adherence in physical activity among older adults.

Exercising outdoors has been shown to contribute to significant improvements in mood, self-esteem and reduce levels of depression among older adults [133]. In order to increase exercise uptake and adherence among older adults in a community setting, a unique purpose-built outdoor exercise park was designed to provide a fun but still physically challenging environment for these older adults. The aims of this study were to provide a more in-depth investigation of older adults' barriers and enablers as well as the perceived health benefits and outcomes in undertaking an exercise intervention using this novel exercise park designed for older adults. Understanding older adults' perceptions can provide an insight to assist in future planning and design of similar outdoor initiatives to increase park-based physical activity among older adults in community settings.

5.2 Methods and Design

The full description of this study's methods, design, randomization process, exercises and tests performed can be found in the full trial protocol previously published [199]. The short-term quantitative outcomes of this study have also been published [218].

5.2.1 Ethics approval and consent to participate

All participants were fully informed about the nature of the study and signed a consent form. This study was approved by the Human Research Ethics Committee of Victoria University, Melbourne (Application ID. HRE13-215).

5.2.2 Design

This study is part of a parallel randomised controlled trial with pre- and post-intervention design (outcome assessments at baseline and at 18 weeks after participation commencement, and number of falls measured over a 12-month period from enrolment in this study) comparing two groups: an exercise park intervention group (EPIG) and a control group (CG). Participants from the EPIG underwent an 18-week exercise intervention with no cost to the participants. Participants in the control group were advised to continue with their usual daily activities and met the research team every two weeks to take part in some social activities (nine meetings of two-hour duration over 18 weeks of participation). As the aims of this study were to identify older adults' barriers and enablers as well as the perceived health benefits and outcomes in undertaking the senior outdoor exercise intervention, only participants from the EPIG took part in the exit interview. The senior exercise park used in this project was provided in-kind by Lappset (Lappset Group Ltd., Rovaniemi, Finland). This exercise park consists of a number of components and stations that aim to work on the following aspects of physical performance: upper body mobility and fine motor skills, balance and coordination, lower limb and upper limb strength, stretching and flexibility (as detailed in this study protocol; [199], https://www.youtube.com/watch?v=lO6jz_w5vcg&;feature=youtube). The study was designed according to the Consolidated Standard of Reporting Trials (CONSORT) guidelines and publications associated with the trial were reported according the CONSORT 2010 Statement [148, 149].

5.2.3 Randomization

Participants were randomly allocated to one of the following groups: (1) Exercise Park Intervention Group (EPIG) or (2) Control Group (CG). Assessors and participants were not blind to their respective group allocation (EPIG or CG). Block randomization stratification by gender using opaque envelopes was undertaken, so that blocks of 12 participants (6 for intervention group and 6 for control group) were randomized at a time. To accommodate couples (e.g. partners/married couples) participation, randomisation by couple also took place.

5.2.4 Inclusion and Exclusion Criteria

Participants were sought via community health promotion events and advertisement in local newspapers, magazines and online social networking media. Participants were also from diverse settings such as local senior organizations, retirement villages, community centres, senior clubs and associations in Melbourne. Thus, older adults who had one or more falls in the previous 12 months or who were concerned about having a fall were recruited for this study. Participants who were generally active and independent in the community with no more than a single point stick used for regular outdoors walking (at least three times per week) were included. More details about inclusion and exclusion criteria are detailed on the study protocol of this study [199].

5.2.5 Characteristics of Participants

Sixty-two older people (mean age of 71.4 ± 6.7 years; 44 females; 18 males) living in the community in Melbourne, Australia volunteered to be part in the study, and 31 of them were randomized to the EPIG whereas 31 were randomized to the CG. The mean age of participants in the EPIG was 72.3 ± 6.2 years, with the majority of participants being females (64%). More than 60 per cent of participants in the EPIG had a history of at least one fall in the last 12 months.

5.2.6 Exercise Program for Participants in the EPIG

The exercise park used in this project consisted of a number of components and stations that aim to work on the following aspects of physical performance: Upper body mobility and fine motor skills, balance and coordination, lower limb and upper limb strength, stretching and flexibility (as detailed on this study protocol [199]). The exercise sessions were provided two times a week (each class approximately 1 to 1.5 hours duration) and were supervised by an accredited exercise physiologist. Each session consisted of 5-10 minutes of warm-up exercises, followed by 45-75 minutes on the equipment stations, and concluded with 5-10 minutes of cool down exercises. The exercise classes contained a maximum of six participants and were circuit based with the warm up and cool down exercises being performed in a group and the core part of the session being carried out in training pairs.

5.2.7 Qualitative Data

Participants allocated to the exercise intervention group were interviewed by an experienced independent qualitative researcher post intervention. An interview guide (see Appendix 3 – Semi-Structured Interview Guide) explored participants' experiences with the project, including the training program (e.g., supervision, frequency, duration, progression of exercises, level of difficulty of exercises, changes to their life in general and general level of satisfaction). The interviews were conducted on an individual basis in a quiet location on the day of their follow-up assessment after the 18-week participation in the exercise intervention. Interviews lasted between 20-40 minutes and were digitally recorded and transcribed verbatim by the qualitative researcher responsible for conducting the interview.

5.2.8 Data Management and Statistical Analysis

After reading participant's interviews on several occasions, they were analysed using a thematic analysis approach [186]. Data were first coded to identify and label text to the participants' experience of the exercise park using both an inductive and deductive approach [219]. The inductive approach allowed for significant themes to emerge from the raw data whereas the deductive approach allowed for the testing of some of the anticipated effects of the intervention. Following this phase, all codes were categorized following classification suggested by O'Cathain and colleagues [219] which can be seen in Fig. 5. Inter-rater reliability was examined by an independent coder on all of the themes and subthemes identified by reviewing a random sample of 10% of all the excerpts relating to each theme and sub-theme with any differences in coding discussed between the coders [187] .

Category	Sub-category
Intervention content and delivery	Intervention development Intervention components Models, mechanisms and underlying theory development Perceived value and benefits of intervention Acceptability of intervention in principle Feasibility and acceptability of intervention in practice Fidelity, reach and dose of intervention Implementation of the intervention in the real world
Trial design, conduct and processes	Recruitment and retention Diversity of participants Trial participation Acceptability of the trial in principle Acceptability of the trial in practice Ethical conduct of trial Adaptation of trial conduct to local context Impact of trial on staff, researchers or participants
Outcomes	Breadth of outcomes Variation in outcomes
Measures of process and outcome	Accuracy of measures Completion of outcome measures Development of outcome measures
Target condition	Experience of the disease, behaviour or beliefs

Fig. 5: Framework of the focus of the qualitative research proposed by O'Cathain and colleagues. Source: [219]

5.3 Results

5.3.1 EPIG Overall Adherence and Attendance Rates

Twenty-seven (i.e., adherence rate of 87%) participants in the EPIG satisfactorily completed the exercise intervention (i.e., had attendance rate greater than 50%). The average attendance to the sessions was 79.6%. Factors like the social interaction promoted by the exercise intervention, the exercise supervision and the physical benefits achieved through the exercise intervention are believed to have influenced the good attendance and adherence rates in this study.

5.3.2 Thematic Analysis

Three main categories were identified from the participants' quotes: "Intervention content and delivery", "Trial Design and Process" and "Outcomes". From each of these categories, several sub-categories were identified. The following sections will describe the extent of the participants' views in relation to the categories/subcategories as described in Table 11.

1. *Intervention content and delivery*

Four first order themes were identified in this category, which are discussed below.

a) *Acceptability of the intervention in practice*

Many participants of this study (11 out of 27) explicitly stated that they enjoyed the experience with the exercise intervention.

"It was just a beautiful experience to go somewhere and exercise that is the main benefit and then laugh while you do it and talk to people. I [had] forgot[ten] about the good old days but they talked about the old theatre and things like that so it was just

wonderful. We used to double up in tears laughing as we exercised." (X-13, female, 69 years old)

Participants also mentioned that they would be happy to continue with the exercise routine developed and that they were keen on continuing attending the sessions if that was possible.

"Oh if I could help in any way yeah for sure [okay and it's something that you could see yourself continuing?] oh for sure yeah yep I'm glad if I can continue that I can continue are they gonna continue it?" (X-39, female, 85 years old)

Four participants reported that they would like to keep their exercise routine but would rather do something else:

"The answer is yes, but I've got the situation where I'd like to do it at home. My long term plan that to not only continue the walking but some of that exercise one that strengthens the back, and I'm quite interested in that, because I'm quite sure that it has been a great benefit." (X-52, male, 80 years old)

b) *Intervention components*

Participants were generally satisfied with the frequency of the exercise sessions as well as the duration of these sessions.

"I think twice a week is excellent. Yes, yes I do. I think that would be a good thing for anyone

I think. Less would probably not be as effective and more would be very hard for anyone to achieve." (X-33, female, 77 years old)

"It was just right. Towards the end, of course, the time was increased, and no we didn't have a problem. We were always asked how we were going and were we getting tired and no it was very good." (X-62, female, 75 years old)

Table 11: Categories and Sub-Categories assigned from the participants quotes and their frequency in the reporting.

Categories/Subcategories	***Total***	***Frequency (%)***
Intervention Content and Delivery	***309***	***64.2***
Acceptability of the intervention in practice	59	12.3
Intervention components	109	22.7
Perceived value and benefits	105	21.8
Implementation of the intervention in the real world	36	7.5
Trial design and process	***85***	***17.7***
Acceptability of the trial in practice	54	11.2
Adaptation of the trial conduct to local context	31	6.4
Outcomes	***87***	***18.1***
Physical outcomes	55	11.4
Psychological outcomes	32	6.7
Grand Total	***481***	***100***

Five participants reported that the exercises matched their capabilities and were progressive in nature.

"I wasn't overly tired at the end of the session not at all… From the exercises I don't… I never felt that they were too arduous they were always within my scope." (X-9, female, 83 years old)

Two participants, on the other hand, mentioned that they would prefer to do something more intense and challenging due to their actual fitness levels.

"Just for me, personally, [I] could have gone probably two minutes to push cos I'm used to pushing myself like with heavy weights and that but just on my own behalf at my

level I would have liked to have put in just a bit more stronger to say "come on let's do you know another fifteen seconds on that!" (X-13, female, 69 years old)

Fifty-six percent of participants commented about being satisfied with the progression of exercises. They mentioned that the different levels for each exercise helped to keep the exercise routine challenging and not repetitive:

"The whole program changed from doing different things. It changed and it wasn't the same old thing every time. And I know that there'll be many different ways that the exercises can be changed. Not actually improved, I think, mainly changing, as I said, so it doesn't become too repetitive. You could see why, when you started to think about it, that it was to make it more difficult, but also to make it so you weren't just becoming a robot." (X-52, male, 80 years old)

However, three participants also mentioned that the progression of exercises from one level to the next could have happened faster given that they thought their physical abilities would allow them to cope with:

"Maybe we could've moved through the exercises a bit more quickly. When I say that I mean, we started off doing them in a particular way, and then we moved to doing them in a more difficult way, and I think maybe that could've been done more quickly than it was. It could've progressed more quickly I think." (X-64, female, 79 years old)

Participants were also satisfied with the quality and safety of the equipment:

"I think everything was very good, all equipment was very safe. It was a test to our ability, I suppose." (X-62, female, 75 years old)

In regard to the supervisory team (exercise physiologists and exercise science students), participants unanimously reported that they found the team to be supportive. Attentive, committed, enthusiastic, knowledgeable, polite and respectful are some examples of terms used to describe the supervisory team:

"I couldn't fault them. Yeah they were great. Friendly, interested in you as a person, and interacted very well and gave me the feeling that I could talk and do the exercises too. No, they were great." (X-7, female, 70 years old)

"There was a very positive attitude, not only with the staff but with other participants, very friendly and I felt the staff went out of their way to be accepting and to make it pleasant." (X-65, female, 72 years old)

c) Perceived value and benefits

Participants valued the social interaction (26%), supervision (16%) and tailoring of the exercise program (7%). Table 12 provides an overview of additional perceived values and benefits reported by participants. Five participants added that the social environment was also beneficial not only to make them feel part of the society again but also to stimulate them to more intensely coordinate different tasks and, consequently, achieve some mental benefits beyond the physical ones:

"The fact that not only was it exercises of the body in a sense, but the little brainbox got made to do things as well, because you get half way through the left hand, the right hand, the left hand and you suddenly have to think it's the left hand and right foot, and that's a lot of thinking and a lot of people would find that beneficial too because it makes them think in a sense rather than just doing it as a robot." (X-52, male, 80 years old)

However, two participants felt initially that the social environment was a little distracting:

"So the whole thing has just been beneficial to me, physically and I think mentally as well, trying to keep up with the chatter of the girls, as I'm the only man there in our group!" (X-63, male, 77 years old)

The fact that the exercise sessions were supervised was also seen as a valuable and beneficial point. Participants reported they felt more confident whilst performing exercises with the exercise physiologists supervising them, respecting and managing their personal abilities and injuries:

"It gives you confidence that there's somebody there beside you to tell you how to do the right thing and that they are watching and you know they are looking after you and that and that's the thing." (X-28, female, 78 years old)

"I had trouble with my knee early on and the exercise was adapted so that I didn't keep on causing pain and could keep going with it. So, they ensured that you didn't injure yourself in any way or make anything worse." (X-23, female, 72 years old)

Table 12: Perceived value and benefits from the exercise intervention and their frequency of reporting.

Perceived value and benefits	***Total***	***Frequency (%)***
Social benefits	32	30.5
Exercise under supervision	15	14.3
Physical benefits	11	10.5
Intervention exercises were adapted to one's needs and capabilities	8	7.6
Mental benefits	7	6.7
Improves balance	6	5.7
Intervention protects from negative events related to ageing	5	4.8
Innovative concept	4	3.8
Intervention provides exercises which are translatable to daily tasks	3	2.9
Good introduction to a healthier lifestyle and way to get back to a physical routine	3	2.9
Improves general well-being	2	1.9
Other varied benefits	9	8.6
Grand Total	***105***	***100***

Some participants highlighted that having a qualified leader coordinating activities and exercises motivated them to come to the sessions. The feedback provided by the exercise physiologists encouraged participants to keep performing the exercises well and to challenge themselves:

"They are also explaining the things what you are doing, mistakes what you are doing, the correct way and also they give the credit and appreciation or something like that. It's quite motivating yeah". (X-29, male, 63 years old)

Participants mentioned that the fact they were being supervised facilitated for them during the exercise session given that they did not need to excessively concentrate on keeping the proper form of the exercises and allowed them to fully enjoy the social interaction.

Participants also reported that the exercise intervention could help to protect them from negative events related to ageing (e.g., falling and losing independence and mobility):

"I think it really is yes it's a program to help maintain your ability to move and to be to maintain control of your life and movements and activities and it helps in areas where you might be a little concerned about your balance or you might be concerned about well certainly about falling or just losing ability it would certainly help and you would benefit greatly from it." (X-38, female, 76 years old)

"It prescribed exercise relating to an older adults' physicality and it actually refocused me that these are the movements that I need to keep really aggressively challenging myself with." (X-55, female, 65 years old)

d) Implementation of the intervention in the real world

Table 13 provides an overview of the points participants thought some improvements can be made. With regard to the latter, participants reported frequency of sessions (i.e., from 2 to 3), its scheduling (e.g., Monday, Wednesday and Friday), free access, better protection from the weather elements, and increase of the intensity of exercises for fitter older adults:

"I think if you could get into fitness, it would be better to have more than twice. For me, it was always a battle because I'm a full time carer at home, but yeah I think probably more would be good." (X-7, female, 70 years old)

"Weather wise when we have rain, we don't have cover. There is no undercover so basically we have to miss that day. So, we miss quite good days because this year we have bit of wet season. So, really, miss maybe three four session or even more because of the rain. We got only that like a cloth cover yeah shade cloth this is something like say um if you have a program in the future you never know which probably you need funding for that or have undercover things you know." (X-44, male, 62 years old)

2. Trial design and process

In regard to the trial design and process, two first order themes were identified.

a) Acceptability of the trial in practice

Most of the participants (20 out of 27) reported to be satisfied with the engagement in the exercise program

"Oh, it was terrific. Happy, motivated, very pleasant to everyone and yeah I think everyone enjoyed it." (X-55, female, 65 years old)

Table 13: Suggestions for improvement of current exercise initiative on future implementations and their frequency of reporting.

Participant's Recommendations/Suggestions for Improvement	***Total***	***Frequency (%)***
Increase frequency	10	27.8
Free access to the park	5	13.9
Indoors rather than outdoors	5	13.9
Increase intensity for fitter older adults	5	13.9
Frequency of exercising days more evenly distributed throughout the week	3	8.3
Progression could have been quicker	2	5.6
attached to a safe place such as a gym	2	5.6
Needs a qualified leader to make it happen	2	5.6
Exercises might get boring if no changes are made.	1	2.8
Dumbbells and some extra small pieces of equipment	1	2.8
Grand Total	***36***	***100***

The high acceptability rate was also expressed in the average rating of 9.4 out of 10 (range 7.5 – 10) when asked to provide a satisfaction score for the exercise program (67% gave a 10). Participants were also happy to recommend the program to family and friends.

"Yeah I recommend it to everyone not only for seniors but to young people. If my daughters can do it then you know it's really good for them too." (X-16, female, 75 years old)

b) *Adaptation of the trial conduct to local context*

The majority of the participants (15 out of 27) reported that weather elements played an important role in the implementation of this initiative.

"You miss you can't do it when it's wet. That is, I suppose, a negative. It's a weather reliant thing. We missed a couple some sessions because of rain and uh yeah that that that's the only downside nothing to do with the program. Meteorological, that was the problem." (X-11, male, 72 years old)

Five participants also highlighted that having the senior exercise park installed on a good and easily accessed location would play a significant role for their uptake and continuous attendance to the sessions. Some participants relied on public transport or had to catch a cab to attend sessions. Likewise, some lived far from the senior exercise park site. They suggested the parks to be installed in areas that are more central and in multiple sites to make access easier to more users. Two participants also mentioned about safety of the surroundings.

"I knew the bus went there and sometimes the walk was a bit tiring especially if it was sunny... It was alright it is quite a long walk but um the whole thing was about fitness anyway." (X-43, female, 65 years old)

3. Outcomes

For Outcomes, three first order themes were identified as described below.

a) Physical Outcomes

The main physical outcomes noticed by the participants were improvement of their muscle strength, balance, gait and flexibility:

"I used to have to use my hands to stand up from sitting on a chair and now I don't have to use my hands anymore that's a big improvement now. I'd say that it improves balance and strength." (X-43, female, 65 years old)

"Walking downstairs, that's my marked one. Whether my gait has improved cos of the program or cos I have an OC daughter who nags [laughter] I'm not sure, but my gait has improved and so I'm walking a greater distance." (X-38, female, 76 years old)

Some participants also noticed they could better perform their activities of daily living (e.g., climbing stairs, picking up things from the floor, tying shoelaces and reaching higher shelves). In that sense, some participants mentioned:

"I've got steps at my place and before I used to go up one step at a time now I'm finding since we've been doing this program I can almost go up with both legs you know it's a little bit hard still but I still try hard you know." (X-10, male, 68 years old)

"I pick things up from the floor more easily um I don't tend to go for the rails to get up the stairs yeah. Yes, it there has been improvement for me". (X-1, female, 78 years old)

One participant highlighted they could catch public transport more easily and could walk faster without easily exhausting themselves:

"Since after about oh even two weeks I wasn't falling getting on and off trams... I was starting to not stumble getting on and off trams that was the first the thing I noticed I was getting on and off trams and almost falling each time, it took me longer for other things to show up like one day at school at um Nicholson street I thought well I'll try the stairs and I found I could actually do it... I didn't know how far into the program that was though but normally I would be stopping up to four times a single flight at least twice each time." (X-43, female, 65 years old)

b) Psychological Outcomes

Fifteen participants mentioned that the exercises helped them to improve their confidence and to make them feel psychologically better after the sessions:

"I felt that when I first started I was a bit because of my knees operation because my knee was operated on and I sort of didn't feel confident in myself and I was always fear the fear was that I may fall so that sort of gave me a lot of confidence. After two months I feel that the something is opening right I feel much more comfortable I more much confident." (X-28, female,78 years old)

"No matter how stressed I was, when I got there I felt so much better after. Just a good belly laugh with a workout you know cos the tension goes so it's good." (X-13, female, 69 years old)

A number of participants reported they felt they had more stamina to do physical activities and were, consequently, trying to be more active and to engage in more outside activities:

"I think I'm more active than I was [really so tell me a little bit more about that] oh well I had become very slack and sloppy about um getting out and walking and that sort of thing [okay] and I had been spending more and more time sitting at the computer [laughter] which is very easy to do [and it's also common] when you don't have you know a lot of um calls on your time and and I have been consciously making the effort to go out and and try to do a bit of a walk instead of just sitting there." (X-23, female, 72 years old)

5.4 Discussion

Participants of the 18-week exercise program using the purpose-built exercise park reported that the exercise intervention was enjoyable, with numerous perceived physical and psychosocial benefits. In combination with the perceived positive influence of the supervisory team, these benefits could explain the high satisfaction, retention and participation rates of the intervention. Possible modifications for future programs are related to the location and seasons (protection from the weather) as well as tailoring progression to individual needs and capabilities.

Participants noticed many positive physical (e.g., improvements in muscle strength, balance, flexibility and gait), psychological (e.g., improved confidence, well-being and reduced depression symptoms) and social (e.g., improved social interaction) benefits from participating in the exercise park intervention. They also mentioned they could better execute activities of daily living (e.g., climbing stairs, tying shoelaces, and catching public transport). These findings are in agreement with the quantitative analysis of the senior exercise park intervention [218] which showed that the 18-week exercise program was effective and safe in improving muscle strength, balance and physical function among older adults using objective assessments.

An important problem among older adults is the low levels of adoption and maintenance of recommended physical activity or exercise levels [70]. The relatively high retention (87%) and participation (79.6%; [218]) achieved in our intervention program might have been in part due to the opportunities for social interaction. Participants highly valued the social interaction provided by the senior exercise park project. Previous research has found that group interventions have been more successful in maintaining physical activity behaviour [198]. In addition, the program design (frequency, intensity, and progression), its delivery by the team, the emphasis on enjoyment during the sessions, and the perceived physical and psychosocial benefits were also factors which may have contributed to the high retention and participation rates.

A number of suggestions were provided for program improvement. These were related to the frequency of delivery (more sessions for able participants) and progression and intensity of the exercises. Higher weekly frequency of engagement in exercise has been associated with increased adherence [220]. However, it appears that exercise interventions of this kind need to provide a balance between exercise frequency and the interference in already existing routines in the participants' life. Future programs might provide an opportunity for participants to exercise more frequently based on individual needs and availability as to minimize perceived conflict with participants' personal life. Similarly, and as implemented in the current trial, it would be recommended to closely tailor programs to the capabilities and progression of participants for the exercises to be beneficial and not harmful for each individual. This, in turn, may maintain motivation and increase participation and retention even further

The presence of an exercise professional would be beneficial and might be initially required until future users of senior exercise parks gain confidence and are familiar with their exercises, especially from a safety perspective. Our study provides further support for the benefits of participation in a supervised exercise program [218, 221-223]. However, giving flexibility for older adults to choose between having an exercise professional or not guiding them through their exercises seems more reasonable given that some people like to exercise more freely and some prefer to exercise under supervision. Offering varied options for older adults with different levels of fitness and needs might enhance their exercise uptake and sustained participation on an initiative of this nature.

The weather elements (sun, rain and wind) were considered key barriers to participation in the current study with some variation in participation rates during the seasons (e.g., summer 86.8% vs. winter 64.3%). The current study took place in Melbourne, Australia which has relatively mild winters and moderate-hot summers. The climate conditions present in Melbourne may not fully represent the possible ranges of climate variations. Thus, it appears that there is a clear need to examine the location of exercise parks, its exposure to the weather elements and seasonal variability [224]. Additionally, the weather also had an influence on perception of safety by participants due to increased risk of slippages or sickness, due to wet and cold weather conditions. However, it is important to note that this trial did not report any adverse incidents with further medical attention being required [218]. The park used was shaded with a non-water proof protection resulting in participants more likely to stay away on days when it was rainy. Although weather might play a role in outdoor exercise participation, it is important to note that exercising outdoors has been shown to have additional mental and emotional benefits (e.g., adult’s relaxation and stress management, positive emotions and mood) compared to indoors [225]. Moreover, having contact with nature through parks can enhance emotional, physical, and spiritual health and well-being which underpins all aspects of health [126].

An issue for any community based intervention is to select a suitable location. The current study was driven by providing an exercise opportunity for older individuals in an area of relatively low socioeconomic status. The final location was not ideal in terms of public transport accessibility. As such, future programs should consider closer collaboration with local councils or community organisations for a more central location of the exercise park so that it could be easily accessed via public transport.

Senior exercise parks are not available in most countries around the world. Countries such as Finland, China, Taiwan, Australia and the United States of America have reported a rapid increase in the amount of general outdoor exercise equipment whose designs and shapes resemble those found in gyms [147, 226]. Previous studies using general outdoor exercise equipment showed that seniors believe they could improve their health by providing not only physical but also social and psychological benefits [226-228]. Although general outdoor exercise equipment might help some older adults, they were not specifically designed for older people to exercise and, for this reason, may not suit or be safe for the abilities and specific needs of older people. Senior exercise parks, however, are designed with the needs and limitations of older people taken into consideration. Therefore, the findings of the present study provide evidence for future implementations of these purpose-built exercise parks and might guide stakeholders, such as councils, urban planners and local authorities on the design of a more inclusive open space areas accommodating a wide range of age groups not only benefitting children and fitter adults.

All in all, it is important to note that the perceptions, opinions and experiences of participants presented in this research paper, although positive, may be different from the experiences and opinions of other older adults in different neighbourhoods, countries, cultures and climate conditions. Therefore, it would be interesting to have the senior exercise park initiative studied in different locations across the globe so that its acceptability and effectiveness among senior citizens could be investigated more widely.

5.5 Practical Implications

Having the installation of these exercise parks in areas offering some amenities such as public toilets, tables and seats is an important point to be noted. Research has shown that access to public toilets has been listed as an enabler for some older adults (mainly women) to exercise [229]. Also important is to have tables and seats where future users can socialise and have some refreshments during and after the exercise sessions. Moreover, we believe that, with simpler and light-to-moderate intensity exercises, motivated older adults may be able to follow instructions if listed in the equipment and attend the sessions on their own volition. This, in turn, would simplify the process of implementing the senior exercise park program as a free accessible physical activity option for older people. Alternatively, supervised sessions might be offered to older adults who prefer to follow an exercise professional or perform higher intensity exercises, or those who are more frail.

5.6 Limitations

While this study provides useful information about the benefits, barriers and enablers for the participation of older adults in an exercise intervention using an outdoor senior exercise park, several limitations are acknowledged. Firstly, our study had a relatively modest sample size. Furthermore, it is believed that the uptake, retention and attendance to this project could have been increased if the senior exercise park had been installed in a location more easily accessible by public transport or if transport would have been provided by the local council or organisations for older people. For future usage and installation of the exercise park, easy access to public transport, climate and park design need to be considered. Finally, a bias in the gender of participants was also noted with more women volunteering to the project (64% of the sample) than men. Women generally assign greater importance to social aspects of program participation than male participants [230, 231]. Despite this potential bias, the variety of perceived benefits reported in this study provided good insight for the perception of older people regarding their participation and engagement in this form of novel exercise initiative.

5.7 Conclusions

The 18-week exercise program using a senior exercise park has been shown to be well-accepted among older adults, and, therefore, may increase older adults' exercise uptake, retention and attendance at outdoor exercise sessions. The exercise intervention proposed was shown to be enjoyable with numerous perceived physical and psychological health benefits as well as relatively high retention and participation rates.

Chapter 6 – The influence of the outdoor senior exercise park intervention in older adults' global and physical self-descriptions and social activity levels

6.1 Introduction

Exercise interventions have been shown to promote a positive impact on overall well-being, exercise self-efficacy and reduction in levels of anxiety in older adults with and without psychological problems [232]. These interventions also improve feelings of loneliness and depression, especially for those who already experience depressive symptoms [70, 233].

It is assumed that, in doing exercise, older adults tend to develop higher levels of self-esteem which has been directly associated to overall well-being and satisfaction with life [234]. Additionally, those with better physical self-perceptions and physical self-esteem have been shown to have higher levels of participation in some form of physical activity or exercise [235].

Not only physical and global self-perceptions can affect older adults' quality of life and overall well-being and self-worth but also the way they have integrated into society. Lack of social interaction and loneliness is a growing concern among the aging population. Evidence suggests that up to one third of older adults may experience some degree of loneliness and social isolation later in their lives [236]. Although loneliness can be a real problem in some older adults' lives, some of them may be more reluctant to admit directly to being lonely unless it is quite obvious or severe [237]. This, on its turn, can silently be contributing to a number of other health problems (both physical and mental) as well as other related problems (e.g., suicide and alcohol consumption) [237].

The literature shows a variety of instruments used to evaluate one's global and physical self-concept and self-perceptions [238]. Acknowledged as a leading multidimensional physical self-concept instrument [239], the Physical-Self Description Questionnaire (PSDQ) was designed to measure 11 aspects of physical self-concept [238]. The PSDQ has been modified and translated to different languages and has consistently shown sound psychometrics across cultures, including Australian, Spanish and Turkish [240]. This questionnaire has demonstrated excellent psychometric properties, including internal consistency, internal validity, and predictive validity, comparable to other self-concept instruments [185]. However, this questionnaire has not been widely used among older adults and there is not much evidence of the relationships between the physical and global self-perceptions, fear of falling and objective measures of muscle strength and physical function.

Psychosocial interventions (e.g., group based exercise interventions) have been shown to improve social activity levels among older adults participating in research trials [241]. Knowing that these interventions can also influence a range of subdomains of physical and global self-perceptions, this chapter aimed to investigate whether these subdomains improve following participation in the 18-week outdoor senior exercise park intervention. Moreover, any improvements or otherwise in global and physical self-esteem and self-perceptions were also examined. Also, this chapter aimed to determine if changes in self-esteem and self-perceptions can influence (e.g., enhance) social activity levels. It is believed that participants who feel better and are more confident about themselves might be more open to socialize more. Therefore, it is hypothesized that older adults with greater global and physical self-perceptions might engage in more social activities over time.

6.2 Methods and Design

The full description of this study's methods, design, randomization process, exercises and tests performed can be found on the full trial protocol previously published [199] and is also available in chapter 3 of this thesis.

6.2.1 Design

Outcome assessments at baseline and post intervention (18 weeks) were taken into consideration for this chapter so that the changes in the global and physical self-perceptions among participants from both groups (EPIG and CG) as well as their changes on their social activity levels/behaviours over these 18 weeks were evaluated. Additionally, it was also analysed how changes in global and physical self-perceptions levels correlate to changes in social activity levels for participants in both groups (EPIG and CG).

6.2.2 Outcome Measures – Physical Self-Description and Social Activity Levels

Global and physical self-perceptions were measured using the Physical Self-Description Questionnaire (PSDQ) – Short Form [185]. The PDSQ is a 40-item questionnaire scored from 1 (false) to 6 (true) and consists of 11 factors: Health, Coordination, Physical Activity, Body fat, Sport, Global Physical, Physical Appearance, Strength, Flexibility, Endurance and Global esteem. The PDSQ has been shown to have good test-retest stability (r = .81 to .94), strong factorial structure and discriminant and convergent validity [185].

Social activity participation was measured with a 10-item questionnaire which was derived from a measure of social functioning [183]. This questionnaire has been previously used to measure social participation in people who had repeated falls [184]. Participants were asked to inform the number of times in the previous two weeks that they have attended in 10 categories of social activities including: gone to church, visiting friends and family, gone to concerts, plays, or sporting events; gone to fairs, museums or exhibits; and attended meetings, appointments, classes/lectures. Questions use a five-value response option (1 = less than once/week; 2 = once/week; 3 = twice/week; 4 = 3–6 times/week and 5 = every day). A summary score of social participation was calculated by adding the value of the answers the participant reported to have undertook on each of the 10 activity categories during the period in question (two weeks). Higher scores are associated with a higher level of social activity (values range from 10 to 50).

Information about the occupation and level of education of participants were collected on their first assessment via a questionnaire (see Appendix 4). On this questionnaire, participants were asked about their highest level of education and their actual or previous occupation. The education level of participants was categorized as “less than high school”, “completion of high school”, or “more than high school” (See Appendix 5, Table A.1). The occupation of participants was individually categorized and classified by work collar-colour (e.g., white-, blue- and pink-collar) and can be seen on Appendix 5 (Table A.2 and Table A.3). This classification was based on Halle’s work as follows: "blue-collar" was referred to skilled tradespeople, factory workers, farmers, and other labourers who usually engages in some type of physical labour that is paid in an hourly rather than fixed wage; "white-collar" was used for workers who perform professional, managerial, or administrative work whereas "pink-collar" was used for professionals who have secretarial or service occupations mainly in positions involving relations with people [242].

6.2.3 Data Management and Statistical Analysis

All analyses were completed using SPSS version 22.0 and a p value less than 0.05 was considered statistically significant. Effect size (η_p^2) with a value greater than 0.14 was considered large whereas 0.01 and 0.06 were considered small and medium, respectively [202]. For all outcome variables repeated measures ANCOVA was performed to examine the difference between groups (EPIG vs CG) and time (Baseline and 18-week assessment) whilst controlling for age. Age was included as a covariate given the decline of many physiological functions which happen with increasing age [203]. The occupation of participants was stratified by worker collar-colour based on the worker collar-colour classification suggested by Halle [242] with the objective to assist in the evaluation of changes in social activity levels of participants. To determine if changes in self-esteem and self-perceptions is associated with (e.g., enhance) social activity levels, the change (Δ) between baseline and 18-week time points for the PSDQ subdomains and for the Social Activity Participation Questionnaire score were calculated. The Pearson product moment correlations (Beta) between these study variables were then computed to determine the bivariate relationships between the change in each subdomain of the PSDQ and change in social activity levels. Analyses of these relationships were run for each group separately to more clearly identify how they occur within the two groups.

6.3 Results

Data from forty-eight participants (mean age of 71.6 ± 6.2 years; 34 females; 14 males) were used in the analyses for this chapter. The mean age of participants was 70 years ± 6 and 72.9 years ± 6.1 for CG and EPIG respectively with the majority of participants being females (81% and 63% in CG and EPIG, respectively). Table 14 provides information about the general characteristics of the participants analysed for this chapter. Information regarding participants' occupation and level of education is provided in Appendix 5 (Table A.1, A.2 and A.3). For participants' occupation, the number of participants in each group based on collar-colour classification (i.e., white-, blue- and pink-collar) was calculated. For the education level of participants, the number of participants who completed less than high school, completed high school, or more than high school was calculated for each group.

There were no significant differences on the outcomes measures between the two groups at baseline. Table 15 provides the means and standard deviation for the PSDQ Subdomains and Social Activity measured in this chapter. Appendix 5 provides further information about the occupation and education level of participants of this study (Table A.1, A.2 and A.3). The majority of participants (52%) in the EPIG completed up to high school level and 41% of them were above this level. On the other hand, 33% of participants in CG reported to have completed up to high school level while 57% reported to be above secondary education level. In regard to the occupation of participants of this study, participants in the EPIG and CG were mostly classified as pink-collar workers (44.4% and 62% respectively).

Table 14: General characteristics of the participants of this study – psychosocial effects

Characteristic	***Control Group (n=21)***	***Exercise Intervention Group (n=27)***
Age (Years)	70±6	72.9±6.1
Gender (Females, n (%))	17 (81)	17 (63)
BMI (kg/m^2)	28.7±5.2	29.3±5.2
Current Smoker (n (%))	2 (10)	1 (4)
Ex-Smoker (n (%))	6 (29)	10 (37)
Daily Alcohol Consumption n ((%))	11 (52)	11 (41)

Table 15: PSDQ and Social Activity measures at baseline and 18-week participation for the CG and EPIG (values are mean ± SD)

Measure	***CG (n=21)***		***EPIG (n=27)***	
	Pre	***Post***	***Pre***	***Post***
PSDQ Subdomains				
Physical Activity	2.7±*1.5*	3.2±*1.4*	2.3±*1.4*	3.0±*1.3*
Physical Appearance	3.1±*1.07*	3.2±*1.2*	3.5±*1.4*	3.6±*1.1*
Body Fat	3.2±*1.7*	2.8±*1.7*	2.8±*1.8*	3.0±*1.5*
Coordination	3.8±*1.0*	4.3±*0.7*	3.9±*1.1*	4.3±*0.9*
Endurance	2.7±*1.2*	2.5±*1.0*	2.2±*1.1*	2.5±*1.0*
Global Self-Esteem	4.6±*1.0*	4.8±*0.6*	4.7±*0.8*	5.0±*0.7*
Flexibility	3.6±*1.0*	3.8±*1.0*	3.3±*1.4*	4.0±*1.3*
Global Physical	4.0±*1.1*	3.9±*0.9*	3.7±*1.4*	4.3±*1.0*
Health	5.1±*1.0*	5.3±*0.6*	5.1±*1.0*	5.0±*0.9*
Sport Competence	2.5±*1.4*	2.6±*1.2*	2.3±*1.3*	2.4±*1.1*
Strength	3.6±*0.9*	3.7±0.7	3.8±*1.3*	3.9±0.9
Social Activity	18.8±*5.8*	19.1±*5.6*	16.7±*3.5*	16.5±*3.6*

PSDQ: Physical Self-Description Questionnaire

6.3.1 Outcome Measures – Global and Physical Self-Perceptions (PSDQ Subdomains)

There was a significant interaction effect between the groups over time for the Global Physical subdomain of the PSDQ and there were medium effect sizes for the Body Fat and Endurance subdomains of PSDQ ($p = 0.08$ and $p = 0.07$, respectively for these two subdomains). However, no significant group or time main effects were observed for any other PSDQ subdomains (see Table 16). Follow-up analysis for the Global Physical subdomain revealed that participants in the EPIG significantly improved their physical self-worth after 18-week exercise participation ($p = 0.02$, 95% CI -0.971 to -0.065) whereas the CG did not.

6.3.2 Outcome Measures – Social Activity Level

There was no significant interaction or group or time main effect for the social activity measure (see Table 16).

6.3.3 Outcome Measures – Correlations between Social Activity Levels and PSDQ Subdomains

Two PSDQ subdomains (i.e., Strength and Coordination) were strongly correlated to changes in social activity levels in the EPIG. Participants with greater changes in their perceptions of coordination and strength levels showed greater changes in their social activity levels (see Table 17). However, when analysing the data of participants in the CG, no correlations between the changes in the PSDQ subdomains and the changes in the social activity levels were observed.

Table 16: PSDQ and Social Activity changes after the 18-week participation for the CG and EPIG

Measure	***p value Group by Time Interaction***	***Interaction Effect η_p^2***	***p value Group Main Effect***	***Group Main effect η_p^2***	***p value Time main effect***	***Time Main effect η_p^2***
PSDQ Subdomains						
Physical Activity	0.59	<0.01	0.29	0.02	0.67	<0.01
Physical Appearance	0.99	<0.01	0.31	0.02	0.72	<0.01
Body Fat	0.08	0.06ǂ	0.89	<0.01	0.41	<0.01
Coordination	0.77	<0.01	0.62	<0.01	0.58	<0.01
Endurance	0.07	0.06ǂ	0.48	0.01	0.25	0.02
Global Self-Esteem	0.75	<0.01	0.52	<0.01	0.20	0.03
Flexibility	0.10	0.05	0.96	<0.01	0.41	0.01
Global Physical	0.02*	0.10ǂ	0.93	<0.01	0.10	0.05
Health	0.29	0.02	0.41	0.01	0.50	<0.01
Sport Competence	0.69	<0.01	0.82	<0.01	0.24	0.03
Strength	0.90	<0.01	0.25	0.02	0.65	<0.01
Social Activity	0.51	<0.01	0.09	0.06ǂ	0.32	0.02

* Significant between groups at the follow up assessment.
ǂ Medium Effect Size. ϕ Large Effect Size. PSDQ: Physical Self-Description Questionnaire

Table 17: Correlations between Changes in the PSDQ Subdomains and Changes in Social Activity for EPIG participants. Values are Pearson product moment correlations

PSDQ Subdomains	***Social Activity***	***p value***
Physical Activity	-0.02	0.90
Physical Appearance	0.09	0.64
Body Fat	0.16	0.42
Coordination	0.45	0.02*
Endurance/Fitness	0.18	0.34
Flexibility	0.24	0.22
Sport Competence	0.04	0.84
Strength	0.46	0.01*
Health	0.19	0.34
Physical Self-Esteem	0.07	0.72
Global Self-Esteem	0.37	0.06

*: $p < 0.05$.
PSDQ = Physical Self-Description Questionnaire

6.4 Discussion

Numerous studies have examined the effect of exercise interventions on the physical functioning (e.g., muscle strength, balance, coordination, and flexibility), falls and fear of falling in community dwelling older individuals [2]. Surprisingly, few studies have examined how global self-esteem and physical self-perceptions change due to participation in exercise interventions. This is important, because both global self-esteem and physical self-perceptions are associated with exercise behaviour [243, 244]. Therefore, this chapter examined how global self-esteem and physical self-perceptions and social activity levels changed as a consequence of participating in the outdoor senior exercise park intervention program. In addition, the relationship between changes in global and physical self-perceptions and change in social activity levels of participants was explored.

After completing the 18-week exercise park intervention, participants in the EPIG showed significant improvements in the Global Physical PSDQ subdomain ($p < 0.01$) which measures how positive participants feel about their physical self [185]. Although the Strength, Endurance, Flexibility and Physical Appearance PSDQ subdomains have been shown in a previous study to be strongly correlated with the physical self-concept PSDQ [245], no significant improvements in these four subdomains were found in this present study. It has been reported that, for older adults to present significant improvements in these subdomains of physical self, they may need longer interventions given that these self-perceptions take longer to change among older adults [246]. The absence of significant improvements on these specific subdomains may have been due to the relatively short duration of the exercise intervention. It also takes longer to enhance perception of physical functioning among older individuals [246].

To date, the PSDQ has mainly been used in young adolescents [245]. It has been speculated that the subdomains for physical self-worth are different for older adults when compared to younger adults [247]. These authors suggest that the needs and problems faced in older age are different from the ones faced at a younger age. Therefore, the subdomains for physical self-worth would be more varied and complex in older people than for younger adults. For example, an older person may struggle to do a simple daily task such as to tie their shoelaces due to a lack of flexibility which is likely to influence their physical self-perceptions. Although the psychometric properties of the PSDQ has been validated in older population [185] and cross-sectional studies have shown relations between the PSDQ domains and physical functioning parameters, the predictive validity of the PSDQ in samples of older individuals is limited.

Cross-sectional relationships have been found between physical self-perceptions and objective measures of strength and physical functioning [248]. However, few studies have observed a relationship between changes in physical functioning following participation in an exercise intervention and physical self-perceptions [249]. Although the outdoor senior exercise park intervention found improvement in a number of physical variables, they were not accompanied by improvements in self-perceptions (e.g., strength). It could be that these changes were not large enough for the participants to report improved physical self-perceptions. Furthermore, although participants of the EPIG did not perceive themselves as stronger or with an improvement in their global self-esteem after completing the exercise intervention, they reported in their exit interviews that they were feeling better and stronger among other perceived benefits after concluding their exercise participation (as reported in chapter 5). These qualitative findings provide some support to suggest that the PSDQ might not be sensitive enough for intervention studies with older individuals to detect changes over time. Additionally, factors such as visual problems, writing and reading difficulties or a general unfamiliarity with completing questionnaires could have contributed to these inconsistencies between what is being verbally reported (i.e., interview) and what is being reported in the PSDQ questionnaire [250].

Among older adults, four subdomains have generally been hypothesized to underline physical self-worth: physical condition, attractive body (physical appearance), physical strength, and sport competence [251]. Some researchers, however, have found no influence of sport competence on physical self-worth among older adults [214] while others did not include sport in their studies as they did not consider it as an appropriate activity in a sample of older adults [252, 253]. The findings of the present study also found that self-perception of sport competence was not related to physical variables or changes over time.

PSDQ subdomains such as Health Status and Body Fat, although under-reported in the literature, have also been reported to be important in older adults for the development of a positive physical self-worth among older adults [185]. However, in the current study, no significant changes were reported in these subdomains even though participants had a significantly higher positive physical self-worth. The development of the PSDQ is based on the assumption that the self is a multidimensional and hierarchical in nature [120]. The hierarchical nature suggests that self-esteem or global self-worth is at the apex. At the middle of the hierarchy are perceptions about the self in more general domains (e.g., physical, social, academic) and at the base of the hierarchy are the perceptions of behaviour and functioning in specific situations (e.g., health, strength). Global self-worth is assumed relatively stable over time with the lower levels more susceptible to change. The finding the physical self-worth increased significantly in the intervention group but not the lower levels domains could be due to the fact that there were small changes in these domains which together made the individuals feel better about their physical self. Finally, it has to be acknowledged that the self-perceptions are made against a particular internal or external frame of reference (i.e., the way a person perceives him/herself at a particular point in time) [121]. It is possible that participation in an exercise intervention changes their frame of reference which, in turn, would result in no change in the PDSQ subdomains.

An important limitation of the present study is the relatively small sample size. In addition, the participants were in relatively good health. As such their physical self-perceptions were relatively high compared to other studies [254]. In combination with the relatively short intervention period this might also explain the lack of improvement in most physical self-perceptions.

No significant improvements in the levels of social activity were observed. Participants of both groups did not report high levels of social activity at the beginning of the project and maintained the same social activity routine throughout the research period. The lack of change (e.g., increase) in their social routines may have been due to their socioeconomic status rather than other factors such as mobility difficulties or fear of falling [255]. Participants from this study came mostly from the western and northern suburbs of Melbourne, which comprise one of the areas of lowest income and more socioeconomic disadvantage in Melbourne [34]. Moreover, social activity participation level has been shown to be influenced by a number of variables such as ethnicity, education level and work status, and the higher the education level, the higher the social activity participation [256]. Further investigating the education level of participants in the EPIG (see Appendix 5, Table A.1), the majority (52%) of participants in EPIG completed up to high school level. In addition, when evaluating their occupation (see Appendix 5, Table A.3), most of them were or used to be pink- and blue-collar workers. Furthermore, income, occupation, or class position in the broader sense was shown to determine lifestyle behaviour (e.g., cultural choices and outings) [37]. Although income of the participants has not been collected in the present study, it is speculated that the lack of changes in the social activity participation observed may have been partly related to the lower education level and lower class position of participants (i.e., being predominantly pink- and blue-collar workers), however, this assumption needs to be further elucidated.

Another explanation for the lack of change in social activity might be related to the appropriateness of use of the instrument in capturing social activity/participation. The Social Activity Participation Questionnaire used in this project collects information predominantly about one specific dimension of social activity (i.e., paid outings such as going to museums, concerts or movies) and hence may not provide adequate information about loneliness or social isolation. Other indicators of social isolation such as social connectedness (e.g., small social network and infrequent participation in social activities) and self-perceived isolation (e.g., loneliness and perceived lack of social support) are needed to be assessed to better capture the social status of the participant.

One of the aims of this study was to explore whether changes in some of the PSDQ subdomains would be correlated to change in social activity levels. A strong significant correlation between the changes in the PSDQ subdomains coordination and strength and change in levels of social activity was found (for participants in the EPIG although not found for participants in the CG). Thus, improvement in participants' perception towards their coordination and strength levels were associated with a change in their social activity levels.

However, in light of the results observed in this sample (i.e., lack of significant changes in the measure of social activity participation over time), the interpretation of this correlation is limited. Moreover, the possible limitations of the instrument used, as discussed in previous paragraphs, makes difficult to draw a more precise conclusion about the influence of one's self-perceptions (e.g., global and physical) in their levels of social activity. Nevertheless, this correlation shows a different perspective about the relationship between one's self-perceptions and their levels of social activity which should be explored in future studies. As discussed in Appendix 6, one's attitudes, actions and behaviours are guided by their beliefs and perceptions [257, 258] and, specifically in this case, global and physical self-perceptions might also influence social activity participation in older adults.

6.5 Conclusions

This study provided further insight regarding a broader range of older adults' global and physical self-perceptions changes after participating in the outdoor senior exercise park intervention. It was found that participants from the EPIG group significantly improved their physical self-worth after 18-week exercise participation. However, no significant changes were reported in regard to their global self-esteem. Additionally, no significant changes in the levels of social activity were reported after participation in the exercise intervention. Therefore, the hypothesis seven that participants would have significant changes in these three mentioned variables has not been confirmed. Finally, this study was able to show a strong correlation between improvements in perceptions of coordination and strength levels and change in social activity levels among older adults as earlier hypothesized (i.e., hypothesis eight).

Chapter 7 – The carry-over effects, sustained benefits and physical activity behaviour among older adults 8 weeks after completion of the exercise intervention

7.1 Introduction

The physical and psychosocial benefits achieved by older adults participating in some form of exercise program on a regular basis are well known [259-261]. However, even with the availability of numerous exercise options, adherence or even participation in less formal forms of physical activity (e.g., walking) are relatively low among older adults [189]. Only 39% of the population aged 65 years and over in Western societies manages to meet the American College of Sports Medicine Guidelines for physical activity which states that every adult should accumulate 30 min or more of at least moderately intense physical activity per day [262].

Exercise interventions, mainly supervised ones, have been successful in increasing physical activity among older adults [263]. However, research has shown that 50% of participating older adults drop out during the first six months of participation [264]. Even participants who conclude the research intervention tend to present a moderate decline of the intervention effects over time [265]. In addition, these older adults show a general decline in their physical activity behaviour after the cessation of the intervention with older adults mostly falling back into their initial routines [265].

Several barriers have been reported to explain discontinuation to exercise participation by older adults after cessation of a research intervention. These include insufficient time, lack of social support, no place to exercise, no transportation to an exercise site, and insufficient money to either buy exercise equipment or join an exercise facility [266]. Additionally, fear of falling and fear of injury while exercising are also significant barriers [266].

Another barrier is that research interventions conducted in controlled settings often do not transfer to other settings. After concluding their research participation, participants would potentially feel unsure about where to go and what to do given that the community setting usually does not reflect the controlled conditions they had during the research intervention or may not be able to accommodate their varied needs. This results in diminished opportunity for the participants to continue the newly adopted and practiced behaviour. A number of reasons have been provided for preventing translation and dissemination of research findings into healthcare practice. These include insufficient local expertise to roll out community exercise programs, lack of research-to-practice data, gaps in the current guidelines regarding how to prescribe appropriate interventions or implement and integrate them into routine clinical and community practice [267].

Most physical activity interventions under research environment for older adults often do not conduct an evaluation of the outcome changes a period after the cessation of the intervention (follow-up) and, therefore, there is limited information about the carry-over effects and sustained benefits beyond the research trial [116, 268]. Also, there is limited evidence about the influence of these research interventions on the actual levels of physical activity post-participation. Therefore, the aim of this chapter was to evaluate which physical measures evaluated in the first study (e.g., muscle strength, balance and physical function) and health related measures (e.g., fear of falling and quality of life) among the participants who completed the 18-week exercise intervention were sustained (carry-over effects) after an 8-week period post-intervention. Secondary aims were to identify if participation in the exercise intervention has affected participants' physical activity behaviour 8-week post intervention or whether they return to their initial habits and routines.

7.2 Methods and Design

The full description of this study's methods, design, randomization process, exercises and tests performed can be found on the full trial protocol previously published [199] and is also available in chapter 3 of this thesis.

7.2.1 Design

Outcome assessments post intervention (18 weeks) and two months after cessation of the intervention (26 weeks) were taken into consideration for this chapter so the carry-over effects and sustained benefits among participants of the senior exercise park intervention after the cessation of the exercise intervention (26 weeks) were evaluated.

7.2.2 Primary outcome: The Balance Outcome Measure for Elder Rehabilitation (BOOMER)

As previously described in the study protocol, the BOOMER battery test was used as the primary outcome to assess the effectiveness of the novel purpose-built exercise park in improving balance. This test comprises four well validated clinical measures (step test [153], timed up and go (TUG) [154], functional reach (FRT) [155], and static standing balance [156]) [158].

7.2.3 Secondary Measures – Strength and Physical Function

The same secondary measures described in chapter 4 comparing baseline data to data post intervention (18 weeks) were used for comparisons at this new time point (26 weeks). As such, we compared measures of balance, muscle strength, mobility and physical function in older adults (e.g., single leg stance test [200], the hand grip strength of both hands [163] and the two-minute walk test [166]). Lower limb strength was assessed via the 30-second sit-to-stand test [169] and measurement of the strength of the knee extensor muscles using a purposely built force transducer [49]. Finally, the assessment of gait speed was performed with the use of the GaitRite® system (CIR System, Inc, Harverton PA) instrumented walkway system.

7.2.4 Secondary Outcomes – Health Related Quality of Life and Psychological Measures

For evaluation and comparisons of the individual health status after 18-weeks of exercise participation and 2 months after cessation of participation, the Short Form (12) Health Survey Version 2 (SF-12v2™) was used [176]. The Short Falls Efficacy Scale International (Short FES-I) questionnaire was used to record fear of falling [201].

7.2.5 Secondary Outcomes – Physical Activity Levels

The Incidental and Planned Exercise Questionnaire (IPEQ) for older people was used to assess the physical activity level and possible changes on the physical activity behaviour of the participants [269]. The IPEQ is a self-report questionnaire that covers the frequency and duration of several levels of planned and incidental exercise in older people. Planned activities (6-items) include planned exercise or walks whereas incidental physical activities (6-items) include day-to-day activities like housework or gardening. Total hours per week spent in both incidental and planned exercise were obtained by multiplying frequency scores and duration scores. Summation of the incidental and planned physical activity hours per week will also provide a total activity score. A further evaluation was conducted into the data of IPEQ to break down and quantify the type of physical activities participants from both groups had been taking part between the 18 weeks to 26 weeks post intervention period.

7.2.6 Data Management and Statistical Analysis

All analyses were completed using SPSS version 22.0 and a p value less than 0.05 was considered statistically significant. Effect size (η_p^2) with a value greater than 0.14 was considered large whereas 0.01 and 0.06 were considered small and medium, respectively [202]. For the primary and secondary outcome variables repeated measures ANCOVA was performed to examine the difference between groups (EPIG vs CG) and time (18-week assessment vs. 26-week assessment) whilst controlling for age. Age was included as a covariate given the decline of many physiological functions which happen with increasing age [203].

7.3 Results

Data from forty-six participants (mean age of 71.8 ± 6.3 years; 33 females; 13 males) were used in the analyses for this chapter. The mean age of participants was 71.3 years ± 6.7 and 71.4 years ± 6.8 for CG and EPIG respectively with the majority of participants being females (80% and 65% in CG and EPIG, respectively). Two dropouts, one from EPIG and one from CG, were recorded between the 18-week assessment and the 26-week assessment with the main reason for the dropout being the participant not being able to make time to come to the assessment session. The final sample size for CG and EPIG was 20 and 26 participants, respectively. Table 18 provides information about the general characteristics of the participants analysed for this chapter. Table 19 provides the means and standard deviation for the outcome measures of this chapter.

7.3.1 Primary outcome: BOOMER Test

There was no significant interaction effect for the BOOMER, nor was there significant group or time main effect (see Table 19).

7.3.2 Secondary Outcomes – Strength and Physical Function

Although there were no significant interaction effects for the physical measures, there were medium effect sizes for knee strength and sit to stand tests (see Table 19). For knee strength, the CG showed an increase while the EPIG group showed a decrease in strength whereas for the sit to stand test, there was a decrease in the number of repetitions in the EPIG whilst the CG remained the same over the time period. There was a group main effect for hand grip strength with the EPIG group showing higher grip strength compared to the CG. No time main effects were found for any physical measures.

Table 18: General characteristics of the participants of this study – carry-over effects

Characteristic	**Control Group (n=20)**	**Exercise Intervention Group (n=26)**
Age (Years)	71.3±6.7	71.4±6.8
Gender (Females, n (%))	16 (80)	17 (65)
BMI (kg/m^2)	28.0±4.3	29.0±5.7
Current Smoker (n (%))	2 (10)	1 (4)
Ex-Smoker (n (%))	5 (25)	9 (35)
Daily Alcohol Consumption (n (%))	10 (50)	10 (38)

7.3.3 Secondary Outcomes – Fear of Falling and Quality of Life

There were no interaction or time or group main effects for Fear of Falling or Quality of Life variables (see Table 19).

7.3.4 Secondary Outcomes – Levels of Physical Activity

There were no interaction effect or time or group main effect for total levels of physical activity (IPEQ_Total), planned physical activity (IPEQ_Planned) and incidental physical activity (IPEQ_Incidental, see Table 20 and 21). Table 22, 23 and 24 provide further information on how the level of physical activity of participants varied over time. Fifty percent of participants in both groups maintained themselves active doing planned exercise sessions between the 18-week and 26-week follow-ups (Table 22). Also, 75% and 77% of participants from CG and EPIG respectively performed some form of home exercises (Table 23). Cycling, dancing and swimming (30%, 30% and 20%, respectively) were the most cited extra exercise activities participants from the EPIG engaged after finishing the exercise intervention participation (Table 24).

Table 19: Primary and secondary outcome measures at 18-week participation and 26-week participation for the CG and EPIG (values are mean ± SD)

Measure	*CG (n=20)* 18-week	*CG (n=20)* 26-week	*EPIG (n=26)* 18-week	*EPIG (n=26)* 26-week	*P value Group by Time Interaction (95% CI)*	*Interaction Effect η_p^2*	*p value Group Main Effect*	*Group Main effect η_p^2*	*p value Time main effect*	*Time Main effect η_p^2*
BOOMER - Total Score (Out of 16)	13.9±1.3	13.9±1.3	13.9±1.3	14.0±1.2	0.9 (-.56 to .57)	<0.01	0.18	0.02	0.48	<0.01
Physical Measures										
Single Leg Stance (sec)	16.9±9.6	19.9±10.6	16.6±11.0	17.2±11.6	0.36 (-1.99 to 6.69)	0.19ϕ	0.57	<0.01	0.49	0.01†
Knee Strength (N.m)	78.5±32.6	84.4±32.1	92.4±42.8	89.8±28.9	0.08* (-1.93 to 18.92)	0.07ǂ	0.11	0.05†	0.42	0.01†
Hand Grip Strength (Kg)	21.2±8.1	21.6±7.8	26.8±9.4	26.5±10.7	0.95 (-2.48 to 0.90)	<0.01	0.01**	0.13ǂ	0.07	0.07ǂ
Two Minute Walk (m)	148.9±24.1	144.9±24.2	152.6±28.1	149.6±26.7	0.96 (-11.43 to 9.31)	<0.01	0.10	0.06ǂ	0.26	0.02†
Timed Up and Go Fast (sec)	7.2±1.5	6.7±1.4	7.1±1.4	6.98±1.4	0.90 (-0.53 to 0.40)	<0.01	0.40	0.01†	0.38	0.01†
Sit to Stand (reps)	11.2±2.9	11.2±2.6	11.9±3.0	11.1±2.2	0.05* (-0.07 to 1.64)	0.08ǂ	0.32	0.02†	0.34	0.02†
Gait Speed (m/s)	1.34±0.17	1.32±0.20	1.33±0.17	1.33±0.16	0.66 (-7.59 to 3.59)	<0.01	0.63	<0.01	0.23	0.03†
Fear of Falling and Quality of Life										
Short FES-I	10.5±3.5	11.4±5.5	9.2±2.5	9.5±3.2	0.46 (-1.05 to 2.21)	0.01†	0.06*	0.07	0.95	<0.01
SF12 PCS	49.1±7.91	48.9±7.6	46.9±7.56	49.6±8.29	0.53 (-2.20 to 5.14)	<0.01	0.79	<0.01	0.63	<0.01
SF12 MCS	51.4±6.1	51.6±7.9	53.1±9.8	54.5±7.0	0.60 (-3.18 to 5.62)	<0.01	0.29	0.59	0.99	<0.01

BOOMER: Balance Outcome Measure for Elder Rehabilitation. FES-I: Falls Efficacy Scale International. SF12-PCS and SF12-MCS: Physical and Mental Component scores of the Short Form (12) Health Survey (SF-12), respectively. * Trend for significant at $p < 0.05$ for group by time interaction. ** Significant between groups at the follow up assessment. † Small effect size. ǂ Medium Effect Size. ϕ Large Effect Size.

Table 20: Incidental and Planned Exercise Questionnaire values at 18-week participation and 26-week for the CG and EPIG (values are mean ± SD)

Measure	***CG (n=20)***		***EPIG (n=26)***	
	18-week	***26-week***	***18-week***	***26-week***
Levels of Physical Activity				
IPEQ_Total	29.81±*20.23*	28.10±*18.30*	33.85±*15.89*	31.87±*16.56*
IPEQ_Planned	6.20±*7.08*	6.34±*6.18*	6.21±*4.13*	6.16±*6.12*
IPEQ_Incidental	23.60±*16.51*	21.76±*15.21*	27.63±*16.61*	25.70±*14.16*

IPEQ: Incidental and Planned Exercise Questionnaire

Table 21: Interaction effect, group and time main effect from the Incidental and Planned Exercise Questionnaire

Measure	***P value Group by Time Interaction (95% CI)***	η_p^2	***p value Group Main Effect***	***Group Main effect*** η_p^2	***p value Time main effect***	***Time Main effect*** η_p^2
Levels of Physical Activity						
IPEQ_Total	0.84 *(-6.99 to 3.27)*	*<0.01*	0.47	0.01†	0.49	0.01†
IPEQ_Planned	0.88 *(-1.47 to 1.52)*	*<0.01*	0.84	*<0.01*	0.90	*<0.01*
IPEQ_Incidental	0.87 *(-6.97 to 3.19)*	*<0.01*	0.35	0.01†	0.51	0.01†

IPEQ: Incidental and Planned Exercise Questionnaire. † Small effect size

Table 22: Number of participants undertaking planned exercise (exercise classes) between the 18-week and 26-week follow-ups for the Control Group (CG) and Exercise Park Intervention Group (EPIG)

Planned Exercise Classes Post Intervention	***Total (%)***
CG	20 (100)
Participant maintained same amount of planned exercise as in the 18-week follow-up	10 (50)
Modified frequency or duration but kept exercising	8 (40)
Participant decided to start exercising between the 18-week and 26-week follow-up	1 (5)
Participant reduced frequency but has taken other physical activities over the week	1 (5)
EPIG	26 (100)
Participant disconsidered the exercise intervention and is no longer taking exercise classes	9 (35)
Participant is attending more exercise classes post-intervention	3 (12)
Participant kept the same frequency and time or considered exercise intervention	13 (50)
Participant is attending exercise classes but not as frequent	1 (3)
Grand Total	***46***

Table 23: Number of participants performing home exercises between the 18-week and 26-week follow-ups for the Control Group (CG) and Exercise Park Intervention Group (EPIG)

Home Exercises Post Intervention	***Total***	***%***
CG	*20*	
No alterations - Participant kept same frequency or duration of home exercises	7	35%
Participant increased frequency or duration of home exercises	8	40%
Participant decreased frequency or duration of home exercises	5	25%
EPIG	*26*	
No alterations - Participant kept same frequency or duration of home exercises	12	46%
Participant decreased duration or frequency of home exercises	6	23%
Participant increased duration or frequency of home exercises	8	31%
Grand Total	***46***	

Table 24: Number of participants undertaking other exercise activities beyond exercise classes between the 18-week and 26-week follow-ups for the Control Group (CG) and Exercise Park Intervention Group (EPIG)

Other Exercises			
18-week Follow-up	***Total (%)***	***26-week Follow-up***	***Total(%)***
Total Doing Other Exercises – CG	*10*	*Total Doing Other Exercises - CG*	*8*
Cycling	1(10)	Cycling	2(25)
Dancing	2(20)	Dancing	2(25)
Gardening	1(10)	Running	2(25)
Gym weights	2(20)	Table tennis	1(13)
Pilates	1(10)	Water aerobics	1(13)
Run	1(10)		
Water aerobics	1(10)		
Yoga	1(10)		
Total Not Doing Any Other Exercises – CG	*52*	*Total Not Doing Any Other Exercises - CG*	*47*
Total Doing Other Exercises – EPIG	*8*	*Total Doing Other Exercises - EPIG*	*10*
Swimming	2(25)	Cycling	3(30)
Dancing	1(13)	Dancing	3(30)
Gardening	1(13)	Swimming	2(20)
Home weights	1(13)	Yoga	1(10)
Nordic walking	1(13)	Nordic walking	1(10)
Stairs	1(13)		
Cycling	1(13)		
Total Not Doing Any Other Exercises – EPIG	*85*	*Total Not Doing Any Other Exercises - EPIG*	*80*
Grand Total	***18***	***Grand Total***	***18***

7.4 Discussion

No significant differences were observed for muscle strength, balance, and physical function in older adults when comparing the two groups during the follow-up period. However, there was a trend for significant reduction in the knee strength and in the number of sit-to-stands performed among participants in the EPIG at the 26-week time point (8 weeks after the exercise intervention cessation). Furthermore, participants from both groups, at the 26-week time-point, seemed to have maintained the same level of physical activity they had at the 18-week time point.

The primary outcome measure chosen for this study, the BOOMER test battery, presented no significant differences with participants of both groups maintaining the same scores during the intervention and follow-up period. Given the level of independence and health of the participants of this study in both groups, a significant change on this outcome would not be expected to occur during the follow-up period. As discussed in chapter 4 when the pre- and post-intervention effects were compared, the lack of improvement or changes observed could be a reflection of a ceiling effect suggesting this test battery may not have been suitable to be used on a sample of independent and mostly healthy community-dwelling older adults. Similarly, with relatively high functioning and independent older people, no significant difference in the outcome measures of quality of life and falls efficacy were found between the groups over time.

The positive effects of an exercise intervention once it is concluded are quickly washed-off if participants do not keep exercising afterwards [270]. Further investigation into the type of activities participants from both groups had been taking part between the 18 weeks to 26 weeks post intervention period (Table 22 to 24) showed that participants from EPIG did not display significant differences in their level of physical activities (planned and incidental) after the cessation of the exercise intervention. Participants from EPIG tended to engage more in other extra exercise activities such as cycling, swimming and dancing (Table 24). Therefore, it is possible that after the cessation of the exercise intervention, participants may have taken part in incidental physical activities or engaged in more planned forms of exercises which may have prolonged the positive outcomes and benefits previously achieved in this study.

Participants in the CG, as reported on chapter 4 (quantitative analysis), had shown a reduction in their outcome measures from baseline to the 18-week time-point when compared to the participants in the EPIG. At the 26-week follow-up assessment, no significant differences between the groups were found in their outcome measures.

Although the reported total level of physical activity/exercise (IPEQ_Total) (Table 20) did not present significant differences for participants in the CG (Table 21), they seemed to have engaged more in physical activities over this period which might explain the lack of changes in their outcome measures at the 26-week follow-up (Table 24). An increase in the number of participants performing home exercises (Table 23) and other exercises (Table 24) was observed in the CG. It is common, when research participants are allocated to a control group (i.e., not intervention), they might get disappointed and even disposed to report negative or "correct" outcomes [271]. These participants might tend to engage more in other activities (e.g., attend gym sessions, join exercise groups or do more home exercises) possibly not to be left behind while others are supposedly going to benefit from an intervention [272]. Moreover, most participants that volunteer to a research intervention have potentially made a decision about the possibility of taking up more physical activities/exercise into their life (i.e., moved into the action stage as proposed in the Transtheoretical Model of Behavior Change). In the action stage of this model, making a change in habits is typically overt and observable [273]. As participants in the CG would only be offered social activities and an educational falls prevention booklet, that would possibly not satisfy their current expectations given that they had already decided to change their habits. Thus, based on this theoretical perspective, it may explain why participants in the CG engaged in more physical activities/exercises.

Exercises which older adults can more easily relate in their daily lives would possibly help them to get more confident in performing their activities of daily living [211]. Furthermore, functional exercises are more prone to promote behavioural change in older adults [211] and this may encourage them to get more physically active given that they may feel more confident and efficacious to move more [274]. As reported in chapter 5 (qualitative analysis), participants in the EPIG reported to have enjoyed and perceived the benefits of what they did during the exercise intervention period. When someone has favourable and enjoyable experiences with something they went through (e.g., the exercise intervention proposed in this study) and believe that such thing will produce positive outcomes (outcome expectancy), they would be more likely to change their behaviour (i.e., keep themselves active after concluding their participation on a research project) [275]. Keeping themselves active might have helped these participants to prolong their positive outcomes and benefits achieved from the exercise intervention for longer.

Self-report questionnaires have been extensively used in research to measure the physical activity levels and/or changes over time. However, self-report questionnaires may imply some inaccuracy with participants reporting lower or higher levels of physical activity than being truly performed [276]. The physical activity questionnaire (IPEQ) used in this study evaluates the physical activity performed in the last three months. Therefore, given that the 26-week assessment was performed two months following completion of the exercise program, some participants may have included the exercise sessions during the research trial as part of their planned physical activity. This has made difficult to infer the real carry-over effects and sustained benefits of the senior exercise park intervention over the period in question. For future research interventions, an objective method for assessing physical activity such as accelerometers or pedometers would be recommended to be included.

7.5 Conclusions

No significant differences were observed for muscle strength, balance, and physical function in older adults between the two groups at the 18-week time point (exercise program completion) and the 26-week time point (8 weeks after intervention completion). Participants from both groups seemed to have kept similar level of physical activity between the two time-points. Given that the physical activity levels remained nearly unchanged for EPIG participants between the 18-week and 26-week follow-up assessments, the real carry-over effects and sustained benefits of the senior exercise park intervention over the period in question is difficult to be inferred. In addition, lack of changes in their Incidental and Planned Exercise Questionnaire values leads to suggest that this sort of initiative may have helped to promote some behavioural change among participants in the EPIG.

Chapter 8 – General Discussion

8.1 The Senior Exercise Park Project and the Domains of Health

Falls among older adults may precipitate adverse physical, medical, psychological, social and economic consequences [277]. They are also an issue of concern in both developed and developing countries [277]. Accidental falls among older adults, mainly in people over 75 years, are the first cause of accidental death in this population group [38]. When these falls do not result in death, they constitute one of the main causes of disability and are often synonymous to a loss of autonomy and institutionalisation [278]. This may happen mainly because, after having an injurious fall, an older adult may experience difficulties in activities of daily living (ADLs, e.g., walking, bathing and dressing) and instrumental activities of daily living (IADLs, e.g., driving, cooking and shopping) and have an increased risk of early death [279].

Physical activity and exercise have been shown to help to reduce fall risks among older adults [56] mainly due to improvements in physical and physiological factors (e.g., changes in muscle strength, flexibility, balance, coordination, mobility, proprioception, reaction time and gait) [10] and psychological factors (e.g., reduction of fear of falling) [280]. In addition, research suggests that exercise plays a role in the maintenance of cognitive vitality in older age [281]. However, not many older adults take part in the varied falls prevention exercise programmes available to benefit from them. In fact, as previously discussed throughout this thesis, sedentary behaviour among older adults is still a problem to be overcome [70].

The benefits of taking part in physical activity among older adults, however, are not limited to physical and psychological factors as vastly reported in the literature. Indeed, physical activity has been long known to promote improvements in all spheres of health (i.e., physical, mental, emotional and social) and well-being of older adults [282]. However, studies going beyond the well-known physical and physiological benefits of their exercising regularly are not extensively available in the literature although there has been a growing interest in these other domains of health in the last decades. This is important because without observing the effects of the exercise intervention programmes in other domains of health rather than only physical, a more holistic understanding of the benefits of exercise to the health and well-being of older adults would not be achieved.

Therefore, as previously discussed in the introduction and literature review of the present work, this thesis aimed to evaluate the feasibility and effectiveness of an 18-week exercise intervention using the outdoor senior exercise park not only based on the investigation of physical elements of health and well-being among older adults but also how the other mentioned spheres of health would change. This has been addressed mainly by evaluating wider aspects of a community based intervention including social activity participation, self-perceptions, quality of life and reduction of fear of falling, personal behaviours (e.g., changes in exercise participation levels), and the influence of environmental aspects given that exercise sessions were run outdoors and participants would be exposed to a variety of natural elements (e.g., wind, rain and sun).

8.2 Engagement of Older Adults in Exercise Programmes

As previously discussed in Chapter 4, the senior exercise park initiative was shown to be a feasible and effective option for older adults to reduce their risk factors for falls and improve their muscle strength and physical function. As such, hypotheses one and four have been confirmed. Also, this exercise option was well accepted by its participants with good adherence and attendance rates which it is in alignment with hypotheses three and one, respectively.

An important point that may have contributed to the high attendance and adherence rates to the senior exercise park intervention was the fact that the exercise sessions were supervised. Literature has shown that older adults value having a qualified supervisor during exercise sessions [218, 221-223]. The senior exercise park intervention made use of qualified exercise supervisors who, in this specific project, were exercise physiologists. As previously discussed in Chapter 5 and based on the qualitative data collected, it appears that the figure of an exercise supervisor was of great importance. Participants mentioned that exercising under qualified supervision was a bonus and very different from what they would have at the gym. Furthermore, participants tend to participate and adhere more to exercise interventions when they have an exercise supervisor (e.g., an exercise physiologist) closely following them up and monitoring their attendance to sessions [283]. Data of the present study also suggest that having an exercise supervisor looking after this age group population over the exercises sessions, explaining the benefits of the practice of exercise and give meaning to what they are doing (e.g., linking exercises being performed to activities of daily life) would potentially be a facilitator to exercise engagement and participation in this group.

Reasons for participants to take part in and adhere to an exercise intervention has greatly varied in the literature where a motivating factor for some older adults can be a barrier for others. In line with findings of this thesis (see Chapter 5), the main reasons for participants to volunteer to the senior exercise park program were to slow down the losses expected with ageing, to get stronger, to prevent them from having a fall and to control the downward spiral in regard to their physical status. In addition, participants reported that the senior exercise park program would be a good way to come back to some structured form of exercise given that they had not exercised for a long time (if ever) and the concept seemed to be appealing and interesting to them. These findings are similar to what has been previously reported in the literature when the main cited factors that motivated older adults to exercise were to keep themselves healthy and maintain fitness levels [284]. Although health has been reported both as a motivator and a barrier to physical activity among older adults [285], in the present study it was not perceived a barrier. Some of the most cited barriers in this project (See Table 13) were: not having the exercise park installed on a public space (i.e., it was installed in private property area, 13.9%), not having good protection from the weather elements (i.e., outdoor exercises, 13.9%) and not being able to increase the intensity of exercises (e.g., for fitter older adults, 13.9%). Literature has shown that weather does play a role as a barrier to exercise among older adults, and transportation and personal safety are other mentioned barriers [285]. So, addressing these issues would potentially help with the adherence and engagement of more users to the senior exercise park initiative.

8.3 Social Interaction, Enjoyment and Changes in Physical Activity Levels

One of the strengths of the senior exercise park intervention was the way it has been conducted which favoured social interaction among participants before, during and after the sessions. In fact, the social interaction promoted has also been one of the main reasons why participants highly enjoyed their participation and were keen to continue with it if the project was to be implemented in the community (e.g., Chapter 5).

Participants recognized the social benefits as one of the major benefits of this initiative. This is an important finding because lack of social relationships can contribute to depression which is highly prevalent among older adults [286]. Older adults facing depression are, in turn, more exposed to a number of other negative consequences such as functional decline, disability, decreased quality of life, and higher mortality rates [287]. Furthermore, strong social relationships and interaction have been shown to be highly predictive of reduced risk of mortality [288].

Programmes promoting social interaction such as the senior exercise park initiative are of importance because social relationships have been reported to directly or indirectly encourage healthy behaviours [289]. These healthy behaviours may happen mainly because a person will try to be more in conformity with prevailing social norms (e.g., be healthier and self-care) [288]. In this sense, social relationships have been suggested to provide direct control by regulating and facilitating healthier behaviours, or indirect control by instilling norms (e.g., responsibility) conducive to healthier behaviours [290]. Individuals who are higher on personal control have more knowledge about health and are more likely to engage in preventive behaviours (e.g., start exercising) and to reduce risky behaviours (e.g., heavy alcohol or cigarette consumption) [291] than those who are not. Hence, interventions such as the senior exercise park may encourage individuals to adopt a healthier lifestyle and to care a bit more about their bodies and health. In support of this thesis' hypotheses, participants of the exercise park intervention maintained their physical activity levels (planned and incidental physical activities) when they were re-assessed 8 weeks after the exercise intervention had been completed. These participants were able to practically maintain the achieved benefits from the intervention period (i.e., improvements in muscle strength, balance and physical function). Thus, these findings suggest that participants might have engaged in other physical activities after completing their trial participation. In doing so, they would keep themselves active and prevent the positive effects of the exercise intervention from being quickly washed-off. This, in turn, suggest some behavioural change and a potential adoption of healthier behaviours. Interventions which focus on exercise self-efficacy (not measured in this thesis), perceived exercise enjoyment, confidence and satisfaction are more prone to promote behavioural change in older adults [211] and potentially change their physical activity behaviour.

Being satisfied and having fun while exercising is also an important point to be mentioned about the senior exercise park project. It is speculated that participants would be motivated and happier when exercising through active fun and challenging exercise stations than through a strict exercise program with very conventional movements such as mostly observed at gyms. The senior exercise park initiative provided older adults with an enjoyable and varied exercise experience so that functional exercise tasks (e.g., climbing stairs and coordinated taps – Table 1) were being performed at the same time that participants chatted to each other and had fun. Although some participants reported to feel a bit overwhelmed with these (indirect) dual task requirements of the exercises (i.e., exercise and socialize at the same time), this practice is still believed to bring positive outcomes because it would indirectly expose participants to more mental stimuli via divided attention while the exercises are being performed [292].

The social interaction and its enjoyment promoted during exercise interventions did not necessarily lead to changes in social activity participation outside of the exercise intervention context, rejecting one of this thesis' hypotheses. In fact, when analysing the data of the Social Activity Participation Questionnaire used in this project, participants in the EPIG did not present significant changes in their social activity levels before and after the exercise intervention. As previously discussed in Chapter 6, many factors may have contributed to the absence of improvements in this variable (e.g., the level of education, occupation and socio-economic status of participants as well as the limitations of the instrument itself). Although other studies have shown that participants really value the opportunities for social interaction promoted by exercise interventions and see this as a big motivator for participation [293], this social interaction does not necessarily contribute to changes in social networks and social participation [294]. In all, this requires further research on this topic.

8.4 Outdoor Exercise and Its Benefits

A novel aspect of the senior exercise park is the fact that the exercise sessions were run outdoors giving its users a chance of breathing some fresh air and get more exposed to sunlight. Over the past decade, several articles have been published about the health benefits of sunlight exposure such as vitamin D levels [295].

Few participants in the EPIG (13.9%), although successfully completing the established exercise intervention period, reported that future participation in an outdoor exercise program would be dependent on the installation of a weather-proof protection over the exercise park area to protect from the weather elements. This percentage of participants not enjoying outdoor exercises, although small, was a surprising finding. It was thought that outdoor exercises would be more appealing to their participation than detrimental. This assumption was based on the literature which has shown that older adults prefer to exercise outdoors rather than indoors [133] although some also find it hard to exercise outdoors when it is cold or windy because it may increase pain if they present arthritis in some of their joints [296]. It is important to note that even with these participants not being fully satisfied with exercising outdoors, the overall adherence rate of the senior exercise program was still relatively high at the end of the project (i.e., 86%, See Chapter 4). Although weather is a factor to be considered when designing an outdoor program, it did not significantly influence seasonal attendance and overall attendance to the exercise sessions, rejecting one of the hypotheses of this thesis.

It is believed that regions where there is less variability in the weather conditions might be more suitable for the installation of such initiative. Otherwise, to make it also viable in regions with more weather variability such as Melbourne, organizations responsible for these parks may need to consider investment in water-proof or natural green sun protection (i.e., installation of the park under a tree to promote sun shade) for the safety of their users. This is primarily important for the safety of participants given that some parts of the equipment may become slippery when wet or participants can be exposed to heat exhaustion when exercising in hot days and in direct exposure to sunlight. In that regard, older adults who enjoy to exercise outdoors have mentioned that the temperature which work better for them to exercise outdoors is between 23 and 28°C [297]. So, it would be possibly wiser and safer to avoid running outdoor exercise sessions for older adults in days or times which temperatures exceed 30°C or are extremely humid. Also, it may be better to run these exercise sessions relatively earlier in the morning or end of the afternoon when temperatures tend to be milder.

All in all, even with some equivocal participants' opinions and feedback about exercising outdoors and their exposure to weather elements, exercising outdoors may be more beneficial and positive to older adults than negative if some measures as previously suggested (i.e. water-proof and sun-proof protection) are taken. This is supported by recent findings in the literature which showed that outdoor exercises, when compared to indoors, promoted a myriad of positive outcomes such as adult's relaxation and stress management, positive emotions and improved mood [225]. Furthermore, outdoor exercises were shown to promote direct and positive impact on individual well-being [124]. This is important among older adults who are more prone to have problems affecting their quality of life and well-being. Finally, outdoor exercise has also been reported to be more restorative (i.e., have the ability to restore health or well-being) and a predictor of exercise frequency (i.e., individuals tend to exercise more often when performing outdoor exercises) [136].

8.5 Translatability and Transferability of the Senior Exercise Park Project to the Real World

Translating and disseminating the research findings of randomized controlled trials into the community and real world is still a problem to be solved. There are still major obstacles such as lack of evidence of the transferability of efficacious trial results to clinical and community settings, insufficient local expertise to roll out community exercise programs, and inadequate infrastructure to integrate evidence-based programs into clinical and community practice refraining these exercise interventions to be further and properly implemented in the real world [267]. In fact, with so much evidence available in the literature reporting the effectiveness of many different types of exercise interventions in preventing falls and reducing falls risks among older adults, it is surprising that very few of them have indeed been adopted and further implemented in the real world, clinical or in community practice [298].

Translatability of exercise interventions such as the senior exercise park can be affected by the availability of such equipment in public areas such as public parks and community centres. It is believed that public parks and community centres would be ideal places for the installation of such exercise parks which are specifically designed for older adults and different from existing children's playgrounds available in public spaces. These public places are mostly easy to access and free of charge to their users (as previously discussed in Chapter 2 and Chapter 5), which are relevant points to consider in terms of facilitating older adults' engagement and adherence to exercise programmes. Furthermore, having the installation of the senior exercise park in areas offering some amenities such as public toilets, water fountain, tables and seats is an important point to be noted. Research has shown that access to public toilets has been listed as an enabler for some older adults (mainly women) to exercise [229]. Also important is to have tables and seats where future users can socialise and have some refreshments during and after the exercise sessions. Literature has shown that exercises sites that are not in a good and central location or in areas with reduced safety and accessibility (e.g., due to heavy traffic, poor availability of pedestrian crossing or not safe footpaths) are mostly unfavourable to exercise participation among older adults [307].However, it is important to note that safety of participants may need to receive some attention when implementing the senior exercise park in public places. The senior exercise park concept is something relatively new and older adults in the community may need to be introduced and be initially instructed about the movements and exercises performed on it (e.g., walking bridge and net stations). Thus, there is some concern that older adults using these parks on their own volition and unsupervised could potentially get injured if they do not receive some information about how to use this equipment (e.g., via a flyer or booklet, clear instructions listed in the equipment next to each station). Finding sponsors to help with the implementation of such programmes becomes difficult not only due to the situation just commented (i.e., potential risk of injuries among unsupervised and more dependent users) but also as some community providers and stakeholders may not have relevant qualified staff to support the program implementation (i.e., training exercise supervisors, determine costs to implement the initiative and deliver sessions per se) [299]. Therefore, enhancing the expertise of these community providers and stakeholders as well as providing financial support to them are crucial points to expand the availability of evidence-based exercise programmes into community settings [267].

Moreover, another point to consider is the simplification of the exercise protocol to demand less supervision of participants. In doing that, not only general implementation of the initiative would potentially be easier but also personnel costs might be reduced. It is also believed that, with easy to follow instructions for light-to-moderate intensity exercises listed on the exercise park equipment, motivated older adults would be able to attend the sessions on their own volition. Alternatively, supervised sessions might be offered to older adults who prefer to follow an exercise professional or perform higher intensity exercises, or those who are frailer. Another option would be the development of a computerized system for mobile devices such as smartphones and tablets to guide users of the senior exercise park about how to properly execute the exercises on each station of the equipment. These systems could offer, for example, videos of the exercises being performed, so older adults would receive some visual examples to help them to more easily understand the exercise options they have in the equipment. However, this option might possibly not attract many older adults because it requires technological skills to install and use this software. An alternative would be to train elderly volunteers to lead supervised sessions and be engaged in community activities. Lack of specific directions and documentation about how a research trial was conducted greatly contributes to make the translation of research trials something less implementable [267]. Hence, the full protocol of the senior exercise park program was previously published and a video demonstrating how exercises are performed was also created (https://www.youtube.com/watch?v=lO6jz_w5vcg&feature=youtube) aiming to allow a wider reach to the exercise intervention protocol and to give details of exercises to be performed in each station and its gradual progression. In having free access to the exercise program prescribed and the mentioned video, other groups interested in replicating the program could more easily adapt this program as needed to their specific groups.

As the weather elements (sun, rain and wind) were cited as potential barriers to participation in the current study, it is suggested that, although installed outdoors, the senior exercise parks can offer some weather elements' protection to its users. As weather had an influence on perception of safety by participants due to increased risk of slippages or sickness, due to wet, cold or too hot weather conditions, protecting participants from the weather would potentially help with their exercise uptake and sustained participation. Specifically in this project, a non-water proof protection was used and it was noticed that participants stayed away on days when it was rainy or too hot. Therefore, it is suggested that a water-proof shade covering the area of the exercise equipment should be considered to enable the exercise park to be fully operational irrespective of weather conditions.

Although this project has not experienced any difficulties with older adults from different cultural backgrounds and non-English speaking languages or older adults from ethnic minority groups, literature has shown that these groups of older adults may require targeted health promotion [195, 285, 300]. It is suggested that interventions providing services that are culturally sensitive should try to meet the following prerequisites: (a) the setting must be embedded in the cultural community, (b) staff administering the intervention should be bilingual-bicultural, and (c) the staff must be sensitive to the cultural nuances within the groups [301]. Moreover, to enhance participation among ethnically and culturally diverse minority older adults, it is suggested that culture-specific exercise are provided and, in the case of the senior exercise park, adapted to each culture [285]. Other suggestions to enhance their participation are to have programs offered at residential sites, classes partnered or offered prior to or after social service programs, to foster relationships among participants and to have families educated about the importance of physical activity for older adults and ways they could help [285]. Finally, to offer low- or no-cost classes and have older adults involved in program development have also been mentioned to enhance participation among these groups [285]. These are important points to make exercise interventions for older adults more likely to success in the recruitment and retention of participants throughout the intervention period or implementation of the programme [300].

The way new concepts and novel exercise program opportunities such as the senior exercise park program are communicated into the community setting has also been shown to influence on the way these opportunities will be successfully received and taken up by their potential users. For example, if a physician recommends the senior exercise program to older adults saying that it is to reduce their risk of falling, these individuals would potentially discard this option because older adults usually rate the importance of falls prevention intervention low or they find this type of program unappealing [195]. However, if the physician prescribes it saying that it will help to keep their fitness levels, independence, autonomy, quality of life and well-being, this same program would probably be much better received and potentially taken up [195]. Literature has shown that promoting fitness as a motivator to exercise can also potentially enhance future exercise behaviour [302]. Interestingly, some authors have found that exercise programmes pitched at level of low-moderate intensity are more well-accepted by older adults than over-challenging or more intense ones [195]. Moreover, receiving the information about the senior exercise program from a variety of sources (e.g., physician, mass media and community centres) and in different languages may also contribute to the way exercise interventions can be more successfully implemented in the real world [195].

Previous research has suggested that a person's attitudes, actions and behaviours are guided by their beliefs [257, 258]. Therefore, interventions to be implemented in the community which aim at reducing falls or fear of falling among older adults should take into consideration global and specific physical self-perceptions of this population group. It is also recommended to couple the consideration of these self-perceptions with strategies such as goal-setting [303], life coaching [304] and behaviour change strategies [274, 305]. In doing this, it is believed that engagement and adherence to interventions aiming to reduce risk of falls and fear of falling are going to be more easily addressed. Moreover, it is relevant that the non-physical aspects of physical activity, such as increasing confidence, are also considered when designing intervention programmes for older adults [197]. In that sense, interventions to enhance physical activity levels and reduce fear of falling should particularly target exercise self-efficacy, perceived exercise enjoyment, confidence and satisfaction in older adults.

8.6 Final Considerations

8.6.1 Scope and Limitations

Participants in this study volunteered predominantly from the Western/Northern suburbs of Melbourne representing a variety of independent living conditions. While the data obtained from this study enabled us to evaluate the feasibility and effectiveness of the outdoor senior exercise parks as well as older adults' acceptability and perceptions towards this initiative, caution must be taken in generalising these findings to a wider Australian population or other older adults' population across the globe. Conducting a similar trial across multiple sites across Australia or the globe would potentially make it possible to evaluate its effectiveness for individuals from different socioeconomic backgrounds and in different climatic regions.

This study had a relatively modest sample size. Additionally, due to budget limitations, this study was not blinded and the principal researcher was conducting the assessments, the randomization and the exercise intervention. Also, a disparity in gender where more females volunteered to be part of this study was observed although there are indeed more older women than men living in Australia [308]. Similarly, there was an unequal number of fallers/non fallers recruited in the study. Therefore, further research is needed with a more homogeneous sample of older adults.

It has been reported that some participants who do not receive their preferred treatment may experience “resentful demoralisation” [151], may not comply with the program structure proposed, may not report accurate responses on the follow-up appointments and may even drop out from the trial [197]. This might have introduced some bias which may have possibly affected the internal validity of the trial. The project tried to control for this by asking participants their preference before randomization. Preference was then taken into account when analysing and interpreting the results. However, it is likely that some of the limitations of randomized controlled trial designs influenced findings.

Moreover, when participants of a research intervention are not allocated to their preferred option in the research project (i.e. the exercise intervention group) and end up allocated to a control group, they tend to engage more in other activities (e.g., attend gym sessions, join exercise groups or do more home exercises) [272]. One of the possible reasons for that could be that they do not want to be left behind while others are supposedly going to benefit from an intervention. Most participants who volunteer to a research intervention have potentially made a decision about the possibility of becoming more active and taking up more physical activities/exercise into their life (i.e., moved into the action stage as proposed in the Transtheoretical Model of Behavior

Change) [273]. In the action stage of this model, making a change in habits is typically overt and observable [273].

As most randomized controlled trials, this project did not control for the potential external engagement on other physical activities or reduction on physical activities levels among participants in the CG. Some of these participants in the CG may have sought alternative treatment or become less active as a response to their disappointment for being randomized to the control group [309]. This, in turn, could potentially show a much bigger effect to the exercise intervention proposed. However, the information regarding changes on their levels of physical activity of participants in both groups was partly evaluated and accounted for in the analyses via the Incidental and Planned Exercise Questionnaire. An alternative would be to measure objectively physical activity behaviour prior to trial commencement using accelerometer and do this again towards the end. Although this is not without limitations and would enhance trial cost significantly.

In addition, some of the participants' improvements reported in this thesis (e.g., muscle strength, balance, physical function and physical self-worth) may have been a consequence of the placebo effect [310]. Literature has shown the effect of encouragement and education on the improvement of outcome measures post-participation in randomized control trials and real clinical settings [311]. For example, participants during the exercise intervention may have received some encouragement and education about the benefits of the exercises they were performing and this may have contributed to the improvements reported. Also, the principal researcher conducting the assessments was also the one conducting the exercise intervention. As a result, some form of relationship between the researcher and the participants might have been developed. Thus, during the re-assessments, participants may have put extra efforts during tests to achieve better results and please the researcher. Although randomized controlled trials are still considered the gold standard in examining the efficacy of interventions there is a realisation that in behavioural change studies (e.g., exercise/physical activity or nutrition) these abovementioned factors may be problematic to the validity of these trials [312].

The BOOMER test battery was chosen as the primary outcome but appeared not adequately sensitive to the population group studied. Previous research on the BOOMER has only used older adults in geriatric and rehabilitation units [157]. Participants in the present study were mostly healthy and independent community dwelling older adults. Hence, the lack of improvement could be a reflection of a ceiling effect or the intervention proposed was not long or intense enough to demonstrate significant improvements in this measure.

It is believed that the involvement, adherence and attendance to this project could have been higher if the senior exercise park had been installed in a location more easily accessible by public transport and in a more central suburb of Melbourne. The exercise park used in this study was installed on a private property (i.e., at the St Bernadette’s Community Respite House, Catholic Homes) and moderately away from public transport. This, in turn, limited participation to those older adults who could drive to the site of the exercise park or organize their attendance by other means (e.g., taxi or family member dropping them off). Furthermore, the location of the exercise park also affected the recruitment of participants whereas installation of the exercise park in more central locations of Melbourne would allow seniors who live in less central suburbs to also volunteer and benefit from this initiative.

The implementation of the senior exercise park project required some financial investments to prepare the land for the installation of the exercise park and to pay for qualified exercise supervisors to ensure safety of participants during exercise sessions. Specifically in this project, this preparation included the application of a soft fall and rubber surfacing to prevent slippages and also promote some cushioning in case of falls. Additionally, it was necessary to pay for a partial coverage of the exercise park area with a non-water proof shade sail to protect participants from direct sunlight in hot days. All of these mentioned points incur initial investment costs. Future studies, therefore, should also consider an economic evaluation of such initiative to examine whether it is a cost-effective way to prevent falls and or reduce health cost associated with falls in older individuals in the community.

Despite these limitations, the results of this study provide new insight on how older adults respond to this novel and unique outdoor exercise program as well the feasibility and effectiveness in reducing fall risks. Furthermore, this study was able to report the possible health benefits and well-being improvements for older people when using the senior exercise park.

8.6.2 Recommendations for Future Research

The findings of the present thesis can guide further larger research trials aiming to investigate the effectiveness of the senior exercise park in reducing the number of falls among older adults living in the community as well as other variables (i.e., cost-effectiveness) not explored in this trial. Therefore, future research could be focusing on the economic cost for implementation and sustainability of this kind of project as well as its cost-effectiveness.

For future trials, location of the exercise park needs to be considered to allow easy access to participants. Moreover, to facilitate the attrition of participants in a control group and to minimise dropout rate, the control group should be offered some other non-physical activities which are perceived as meaningful for older people in combination with social activities rather than solely social activities. Another option would be to offer different research designs. For example, instead of having the control group only receiving usual care, the control condition could be what is called “active control” and “dismantling control” [313] or a “wait list control” [314]. These two first types of control condition are noted to be superior to the usual care control condition [313]. The active control option engages participants in the control group in activities that account for potential treatment effects related to attention received from researchers [313]. A dismantling control condition is one in which an efficacious intervention that has several components is taken apart, often to create a more cost-effective intervention (e.g., a study of weight training and nutrition education could be compared to weight training alone) [313]. The “wait list control” option allows for the provision of care (if delayed) to research participants who are seeking help [314]. This latter option may, however, overestimate intervention effects [315, 316].

One of the reasons for randomized controlled trials in the community to face difficulty when being further translated and implemented is that they are usually conducted in very controlled conditions which often do not transfer to other settings [267]. With the senior exercise park project, given its novelty and unique concept, the eligibility criteria were also limited and strict to participants without serious and uncontrolled comorbidities. This project was the first evidence-based research trial with this new equipment and it would probably be risky to participant’s safety to allow individuals with more serious conditions (e.g., Dementia and Alzheimer’s disease) to volunteer. However, with the positive outcomes and evidence obtained in this first phase of the use of the senior exercise park, frail older adults or older adults with more varied conditions can now be included in future trials and the effectiveness of the senior exercise park in reducing falls risk and improving quality of life and well-being among these high-risk groups can be tested. Moreover, it would be suggested to have the senior exercise park initiative implemented in multiple sites (i.e., neighbourhoods) so that a more diverse group of older adults (e.g., from different socioeconomic demographics, occupation and different levels of education) would be able to volunteer. In doing so, different results related to physical, physiological and psychosocial measures might be observed. Additionally, in dealing with community dwelling older adults from different geographic locations and backgrounds, different barriers to exercise or factors influencing the acceptability of this kind of initiative might be identified.

8.7 Final Conclusions

The outdoor senior exercise park has been shown to be a feasible, safe, and effective option to reduce falls risk (e.g., muscle strength, balance and physical function) among independent community dwelling older adults which was maintained for a short period of time (8 weeks) following the completion of the intervention period. The outdoor exercise program was well-accepted by the participants with high adherence and participation rates being reported. Qualitative data revealed that the exercise intervention was very enjoyable with participants reporting varied perceived benefits (e.g. social interaction). Further, the exercise park was shown to be a potential option for seniors to improve their exercise uptake and sustain participation in physical activity which is still a problem to be overcome among this population group. This thesis also provided some evidence for the importance of self-perceptions for physical activity behaviour. In addition, the intervention programme resulted in a significant increase in participants’ physical self-worth.

Few important aspects to enhance translation and transferability of the senior exercise park intervention into community settings are the consideration of the motivators and barriers for the engagement onto these programs and the venues where these programmes would be run (i.e., outdoors vs. indoors, public parks, easy access and safe and well served spaces). Also of importance for a successful implementation of this program is the way community service providers and stakeholders can prepare and capacitate themselves to support its implementation (e.g., training professionals, and promoting and disseminating the senior exercise park in the community). In doing so, it is believed that the number of older adults having access to this feasible, effective and enjoyable intervention would be potentially maximized.

In summary, the findings of this present thesis provide initial evidence to support future implementations of this purpose-built exercise park in a community setting and might guide stakeholders, such as councils, urban planners and local authorities on the design of more inclusive open space areas which would accommodate a wide range of population groups not only benefitting children and fitter adults.

References

1. Ambrose, A.F., G. Paul, and J.M. Hausdorff, *Risk factors for falls among older adults: a review of the literature.* Maturitas, 2013. **75**(1): p. 51-61.
2. Gillespie, L.D., et al., *Interventions for preventing falls in older people living in the community.* Cochrane Database Syst Rev, 2012. **9**(11): p. CD007146.
3. Tiedemann, A., et al., *Exercise and Sports Science Australia position statement on exercise and falls prevention in older people.* Journal of Science and Medicine in Sport, 2011. **14**(6): p. 489-495.
4. Australian Bureau of Statistics. *3101.0 - Australian Demographic Statistics, Jun 2016*. 2016 15/12/2016 03/01/2017]; Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0.
5. Hua, F., et al. *Falls Prevention in Older Age in Western Pacific Asia Region*. WHO background paper to the global report on falls among older persons 2007; Available from: http://www.who.int/ageing/projects/falls_prevention_older_age/en/.
6. Australia Institute of Health and Welfare, *Hospitalised injuries in older Australians: 2011-12. Injury research and statistics series 90. Cat. no. INJCAT 166*. 2014, AIHW: Canberra.
7. Deandrea, S., et al., *Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis.* Epidemiology, 2010. **21**(5): p. 658-668.
8. Tinetti, M.E., M. Speechley, and S.F. Ginter, *Risk factors for falls among elderly persons living in the community.* The New England Journal of Medicine, 1988. **319**(26): p. 1701-1707.

9. Sherrington, C., et al., *Exercise to prevent falls in older adults: an updated systematic review and meta-analysis.* British journal of sports medicine, 2016: p. bjsports-2016-096547.

10. Kannus, P., et al., *Prevention of falls and consequent injuries in elderly people.* The Lancet, 2005. **366**(9500): p. 1885-1893.

11. Merom, D., et al., *Prevalence and correlates of participation in fall prevention exercise/physical activity by older adults.* Preventive medicine, 2012. **55**(6): p. 613-617.

12. Dishman, R.K. and J.F. Sallis, *Determinants and interventions for physical activity and exercise*, in *Physical activity, fitness, and health: International proceedings and consensus statement* C. Bouchard, R.J. Shephard, and T. Stephens, Editors. 1994, Human Kinetics: Champaign, IL. p. 214-238.

13. World Health Organization. Ageing and Life Course Unit, *WHO global report on falls prevention in older age*. 2008, Geneva: World Health Organization.

14. De Vreede, P.L., et al., *Playgrounds for older adults: a feasibility study.* 2008.

15. Murray, C.J., et al., *Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010.* The lancet, 2013. **380**(9859): p. 2197-2223.

16. Bergen, G., *Falls and fall injuries among adults aged≥ 65 years—United States, 2014.* MMWR. Morbidity and Mortality Weekly Report, 2016. **65**.

17. McCart, J.A., et al., *Finding falls in ambulatory care clinical documents using statistical text mining.* Journal of the American Medical Informatics Association, 2013. **20**(5): p. 906-914.

18. Rubenstein, L.Z., *Falls in older people: epidemiology, risk factors and strategies for prevention.* Age and Ageing, 2006. **35**(suppl 2): p. ii37-ii41.

19. Ageing, W.H.O. and L.C. Unit, *WHO global report on falls prevention in older age*. 2008: World Health Organization.

20. Stevens, J.A., et al., *Gender differences in seeking care for falls in the aged Medicare population.* American journal of preventive medicine, 2012. **43**(1): p. 59-62.

21. Inouye, S.K., C.J. Brown, and M.E. Tinetti, *Medicare nonpayment, hospital falls, and unintended consequences.* New England Journal of Medicine, 2009. **360**(23): p. 2390-2393.

22. Zhang, L.L., et al., *The KAP evaluation of intervention on fall-induced injuries among elders in a safe community in Shanghai, China.* PLoS One, 2012. **7**(3): p. e32848.

23. Granacher, U., et al., *An intergenerational approach in the promotion of balance and strength for fall prevention-a mini-review.* Gerontology, 2011. **57**(4): p. 304-315.

24. Australian Institute of Health and Welfare. *Falls in Older People*. 2013 [cited 2017 01/03/2017]; Available from: http://www.aihw.gov.au/injury/falls/.

25. National Public Health Partnership, *The National Falls Prevention for Older People Plan: 2004 Onwards*. 2004, Canberra: NPHP.

26. Hill, K., et al., *Falls among healthy, community-dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy.* Australian and New Zealand journal of public health, 1999. **23**(1): p. 41-48.

27. Kannus, P., et al., *Fall-Induced Injuries and Deaths Amond Older Adults.* Journal of the American Medical Association, 1999. **281**(20): p. 1895-1899.

28. O'Loughlin, J., et al., *Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly.* American Journal of Epidemiology, 1993. **137**: p. 342-354.

29. Resnick, B., *Falls in a Community of Older Adults: Putting Research into Practice.* Clinical Nursing Research, 1999. **8**(3): p. 251-266.

30. Moller, J., *Projected costs of fall related injury to older persons due to demographic change in Australia: report to the Commonwealth Department of Health and Ageing.* 2003.

31. Gibson, M.J., et al., *The prevention of falls in later life. A report of the Kellogg International Work Group on the prevention of falls by the elderly.* Danish Medical Bulletin, 1987. **34**(4): p. 1-24.

32. Bradley, C., *Hospitalisations due to falls in older people, Australia 2008-09*, in *Injury research and statistics series no. 62.* . 2012, Australian Institute of Health and Welfare: Canberra.

33. West, J., et al., *Do rates of hospital admission for falls and hip fracture in elderly people vary by socio-economic status?* Public Health, 2004. **118**(8): p. 576-581.

34. Australian Bureau of Statistics. *2030.2 - Melbourne ... A Social Atlas*. 2006 28/05/2015]; Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/2030.2/.

35. King, M.B. and M.E. Tinetti, *Falls in community-dwelling older persons.* Journal of the American Geriatrics Society, 1995. **43**(10): p. 1146.

36. Van Dieen, J.H., M. Pijnappels, and M. Bobbert, *Age-related intrinsic limitations in preventing a trip and regaining balance after a trip.* Safety Science, 2005. **43**(7): p. 437-453.

37. Lord, S.R., et al., *Falls in older people: risk factors and strategies for prevention*. 2007: Cambridge University Press.

38. Fuller, G.F., *Falls in the elderly.* American Family Physician, 2000. **61**(7): p. 2159-2168.

39. Resnick, B. and P. Junlapeeya, *Falls in a community of older adults: findings and implications for practice.* Applied Nursing Research, 2004. **17**(2): p. 81-91.

40. Baldwin, R.L., R.F. Craven, and M. Dimond, *Falls: are rural elders at greater risk?* Journal of gerontological nursing, 1996. **22**(8): p. 14.

41. Smith, T., et al., *What activities cause hip dislocation? A review of 100 total hip replacement dislocations*.* Advances in Physiotherapy, 2012. **14**(2): p. 55-60.

42. Soriano, T.A., L.V. DeCherrie, and D.C. Thomas, *Falls in the community-dwelling older adult: a review for primary-care providers.* Clinical interventions in aging, 2007. **2**(4): p. 545.

43. Rubenstein, L.Z. and K.R. Josephson, *The epidemiology of falls and syncope.* Clinics in Geriatric Medicine, 2002. **18**(2): p. 141-158.

44. Inouye, S.K., et al., *Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept.* Journal of the American Geriatrics Society, 2007. **55**(5): p. 780-791.

45. Ganz, D.A., et al., *Will my patient fall?* Jama, 2007. **297**(1): p. 77-86.

46. Tinetti, M.E. and C. Kumar, *The patient who falls:"It's always a trade-off".* Jama, 2010. **303**(3): p. 258-266.

47. Sherrington, C. and S.R. Lord, *Increased prevalence of fall risk factors in older people following hip fracture.* Gerontology, 1998. **44**(6): p. 340-344.

48. Gunn, H., et al., *Risk factors for falls in multiple sclerosis: an observational study.* Multiple Sclerosis Journal, 2013: p. 1352458513488233.

49. Lord, S.R., H.B. Menz, and A. Tiedemann, *A physiological profile approach to falls risk assessment and prevention.* Physical Therapy, 2003. **83**(3): p. 237-52.

50. Landi, F., et al., *Sarcopenia as a risk factor for falls in elderly individuals: Results from the ilSIRENTE study.* Clinical Nutrition, 2012. **31**(5): p. 652-658.

51. Evans, W.J. and G. Grimby, *Muscle performance and structure in the elderly as studied cross-sectionally and longitudinally.* The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 1995. **50**(Special Issue): p. 17-22.

52. Moreland, J.D., et al., *Muscle weakness and falls in older adults: a systematic review and meta-analysis.* Journal of the American Geriatrics Society, 2004. **52**(7): p. 1121-1129.

53. Blain, H., et al., *Balance and walking speed predict subsequent 8-year mortality independently of current and intermediate events in well-functioning women aged 75 years and older.* The journal of nutrition, health & aging, 2010. **14**(7): p. 595-600.

54. American Geriatrics Society, Geriatrics Society, and American Academy Of Orthopaedic Surgeons Panel On Falls Prevention, *Guideline for the prevention of falls in older persons.* Journal of the American Geriatrics Society, 2001. **49**(5): p. 664-672.

55. Granacher, U., et al., *Comparison of traditional and recent approaches in the promotion of balance and strength in older adults.* Sports Medicine, 2011. **41**(5): p. 377-400.

56. Gillespie, L.D., et al., *Interventions for preventing falls in older people living in the community.* Cochrane Database Syst Rev, 2009. **2**(CD007146).

57. Sherrington, C., et al., *Effective exercise for the prevention of falls: a systematic review and meta-analysis.* Journal of the American Geriatrics Society, 2008. **56**(12): p. 2234-2243.

58. Bertera, E.M. and R.L. Bertera, *Fear of falling and activity avoidance in a national sample of older adults in the United States.* Health & social work, 2008. **33**(1): p. 54-62.

59. Fessel, K.D. and M.C. Nevitt, *Correlates of fear of falling and activity limitation among persons with rheumatoid arthritis.* Arthritis Care Research, 1997. **10**(4): p. 222-228.

60. Howland, J., et al., *Fear of falling among the community-dwelling elderly.* Journal of Aging and Health, 1993. **5**(229-243).

61. Lord, S.R., et al., *The effect of an individualized fall prevention program on fall risk and falls in older people: a randomized, controlled trial.* Journal of the American Geriatrics Society, 2005. **53**(8): p. 1296-1304.

62. Zuckerman, J.D., *Hip fracture.* New England Journal of Medicine, 1996. **334**(23): p. 1519-1525.

63. Haentjens, P., et al., *Meta-analysis: excess mortality after hip fracture among older women and men.* Annals of internal medicine, 2010. **152**(6): p. 380-390.

64. Panula, J., et al., *Mortality and cause of death in hip fracture patients aged 65 or older-a population-based study.* BMC musculoskeletal disorders, 2011. **12**(1): p. 1.

65. Gill, T.M., et al., *Restricted activity among community-living older persons: incidence, precipitants, and health care utilization.* Annals of Internal Medicine, 2001. **135**(5): p. 313-321.

66. Chou, W.C., et al., *Perceptions of physicians on the barriers and facilitators to integrating fall risk evaluation and management into practice.* Journal of general internal medicine, 2006. **21**(2): p. 117-122.

67. World Health Organization, *WHO global report on falls prevention in older age*. 2007, World Health Organization: Switzerland.

68. Copeland, J., *Depression of older age. Origins of the study.* The British Journal of Psychiatry, 1999. **174**(4): p. 304-306.

69. Beekman, A.T., et al., *The impact of depression on the well-being, disability and use of services in older adults: a longitudinal perspective.* Acta Psychiatrica Scandinavica, 2002. **105**(1): p. 20-27.

70. Yardley, L., et al., *Older people's views of advice about falls prevention: a qualitative study.* Health Education Research, 2006. **21**(4): p. 508-517.

71. Van Kan, G.A., et al., *Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force.* The journal of nutrition, health & aging, 2009. **13**(10): p. 881-889.

72. Rizzo, J.A., et al., *The cost-effectiveness of a multifactorial targeted prevention program for falls among community elderly persons.* Medical care, 1996. **34**(9): p. 954-969.

73. Robertson, M.C. and L.D. Gillespie, *Fall prevention in community-dwelling older adults.* Jama, 2013. **309**(13): p. 1406-1407.

74. Shigematsu, R., et al., *Dance-based aerobic exercise may improve indices of falling risk in older women.* Age and ageing, 2002. **31**(4): p. 261-266.

75. Petridou, E.T., et al., *What works better for community-dwelling older people at risk to fall? A meta-analysis of multifactorial versus physical exercise-alone interventions.* Journal of Aging and Health, 2009. **21**(5): p. 713-729.

76. Chang, J., et al., *Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials.* British Medical Journal, 2004. **328**(7441): p. 680.

77. Andrews, N.A., *Multifactorial interventions to prevent falls: Is there reason to doubt their effectiveness?* IBMS BoneKEy, 2008. **5**(7): p. 238-242.

78. Campbell, A.J. and M.C. Robertson, *Rethinking individual and community fall prevention strategies: a meta-regression comparing single and multifactorial interventions.* Age and Ageing, 2007. **36**(6): p. 656-662.

79. Paterson, D.H., G.R. Jones, and C.L. Rice, *Ageing and physical activity: evidence to develop exercise recommendations for older adults.* Applied Physiology, Nutrition, and Metabolism, 2007. **32**(S2E): p. S69-S108.

80. Thibaud, M., et al., *Impact of physical activity and sedentary behaviour on fall risks in older people: a systematic review and meta-analysis of observational studies.* European Review of Aging and Physical Activity, 2011. **9**(1): p. 5.

81. Bocksnick, J.G., *Exercising for health: An analysis of semi-structured interviews.* Activities, Adaptation & Aging, 2004. **28**(2): p. 1-17.

82. Chao, D., C.G. Foy, and D. Farmer, *Exercise adherence among older adults: challenges and strategies.* Controlled clinical trials, 2000. **21**(5): p. S212-S217.

83. Schutzer, K.A. and B.S. Graves, *Barriers and motivations to exercise in older adults.* Preventive medicine, 2004. **39**(5): p. 1056-1061.

84. Karlsson, M.K., et al., *Prevention of falls in the elderly: a review.* Scandinavian journal of public health, 2013. **41**(5): p. 442-454.

85. Clemson, L., et al., *Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial.* Bmj, 2012. **345**: p. e4547.

86. Trombetti, A., et al., *Effect of music-based multitask training on gait, balance, and fall risk in elderly people: a randomized controlled trial.* Archives of internal medicine, 2011. **171**(6): p. 525.

87. Pate, R.R., et al., *Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine.* Jama, 1995. **273**(5): p. 402-407.

88. Harvey, J.A., S.F. Chastin, and D.A. Skelton, *Prevalence of sedentary behavior in older adults: a systematic review.* International journal of environmental research and public health, 2013. **10**(12): p. 6645-6661.

89. Mazzeo, R.S., et al., *ACSM Position Stand.* Medicine & Science in Sports & Exercise, 1998. **30**(6): p. 992-1008.

90. American College of Sports Medicine, *ACSM's guidelines for exercise testing and prescription*. 2014, Philadelphia: Lippincott Williams & Wilkins.

91. Chodzko-Zajko, W. and A.C.o.S. Medicine, *ACSM's exercise for older adults*. 2013: Lippincott Williams & Wilkins.

92. Begg, S., et al., *The burden of disease and injury in Australia 2003.* 2007.

93. Australian Bureau of Statistics. *4364.0.55.001 - National Health Survey: First Results, 2014-15* 2015 08/12/2015 04/01/2017]; Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/4364.0.55.001.

94. Nelson, M.E., et al., *Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association.* Circulation, 2007. **116**(9): p. 1094.

95. Bennie, J.A., et al., *The descriptive epidemiology of total physical activity, muscle-strengthening exercises and sedentary behaviour among Australian adults – results from the National Nutrition and Physical Activity Survey.* BMC Public Health, 2016. **16**(1): p. 73.

96. Armstrong, T., A.E. Bauman, and J. Davies, *Physical activity patterns of Australian adults: results of the 1999 National Physical Activity Survey*. 2000: Australian Institute of Health and Welfare.

97. Sims, J., et al., *Physical activity recommendations for older Australians.* Australasian Journal on Ageing, 2010. **29**(2): p. 81-87.

98. Taylor, W.C., T. Baranowski, and D.R. Young, *Physical activity interventions in low-income, ethnic minority, and populations with disability.* American journal of preventive medicine, 1998. **15**(4): p. 334-343.

99. Vos, T., et al., *Burden of disease and injury in Aboriginal and Torres Strait Islander Peoples: the Indigenous health gap.* international Journal of Epidemiology, 2009. **38**(2): p. 470-477.

100. Bethancourt, H.J., et al., *Barriers to and facilitators of physical activity program use among older adults.* Clinical medicine & research, 2014. **12**(1-2): p. 10-20.

101. Biedenweg, K., et al., *Understanding Older Adults' Motivators and Barriers to Participating in Organized Programs Supporting Exercise Behaviors.* The Journal of Primary Prevention, 2014. **35**(1): p. 1-11.

102. Robertson, M.C., et al., *Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: Randomised controlled trial.* Bmj, 2001. **322**(7288): p. 697.

103. Booth, M.L., A. Bauman, and N. Owen, *Perceived Barriers to Physical Activity Among Older Australians.* Journal of Aging & Physical Activity, 2002. **10**(3): p. 271-280.

104. Chinn, D.J., et al., *Barriers to physical activity and socioeconomic position: implications for health promotion.* Journal of Epidemiology and Community Health, 1999. **53**(3): p. 191.

105. Bandura, A., *Self Eflicacy. The Exercise of Control, New York: W H.* Freeman & Co. Student Success, 1997. **333**: p. 48461.

106. Clark, D.O., *Physical activity and its correlates among urban primary care patients aged 55 years or older.* The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 1999. **54**(1): p. S41-S48.

107. McSweeney, J.C. and S. Coon, *Women's inhibitors and facilitators associated with making behavioral changes after myocardial infarction.* Medsurg nursing, 2004. **13**(1): p. 49.

108. Picorelli, A.M.A., et al., *Adherence to exercise programs for older people is influenced by program characteristics and personal factors: a systematic review.* Journal of physiotherapy, 2014. **60**(3): p. 151-156.

109. Nielsen, G., et al., *Health promotion: The impact of beliefs of health benefits, social relations and enjoyment on exercise continuation.* Scandinavian journal of medicine & science in sports, 2014. **24**(S1): p. 66-75.

110. Minichiello, V., J. Browne, and H. Kendig, *Perceptions and consequences of ageism: views of older people.* Ageing and Society, 2000. **20**(03): p. 253-278.

111. Weeks, L. and K. Roberto, *The impact of falls on quality of life: empowering older women to address falls prevention.* Quality in Ageing and Older Adults, 2003. **4**(3): p. 5-13.

112. Rhodes, R.E., et al., *Factors associated with exercise adherence among older adults.* Sports medicine, 1999. **28**(6): p. 397-411.

113. Ashe, M.C., et al., *Older adults, chronic disease and leisure-time physical activity.* Gerontology, 2008. **55**(1): p. 64-72.

114. Costello, E., et al., *Motivators, barriers, and beliefs regarding physical activity in an older adult population.* Journal of geriatric physical therapy, 2011. **34**(3): p. 138-147.

115. Ashworth, N.L., et al., *Home versus center based physical activity programs in older adults.* The Cochrane Library, 2005.

116. Van Der Bij, A.K., M.G. Laurant, and M. Wensing, *Effectiveness of physical activity interventions for older adults: a review.* American journal of preventive medicine, 2002. **22**(2): p. 120-133.

117. Wolin, K.Y., et al., *Long-term physical activity patterns and health-related quality of life in US women.* American journal of preventive medicine, 2007. **32**(6): p. 490-499.

118. Conn, V.S., et al., *Integrative review of physical activity intervention research with aging adults.* Journal of the American Geriatrics Society, 2003. **51**(8): p. 1159-1168.

119. Fox, K.R., *The influence of physical activity on mental well-being.* Public health nutrition, 1999. **2**(3a): p. 411-418.

120. Shavelson, R.J., J.J. Hubner, and G.C. Stanton, *Self-concept: Validation of construct interpretations.* Review of educational research, 1976. **46**(3): p. 407-441.

121. Marsh, H.W., et al., *Structure of physical self-concept: Elite athletes and physical education students.* Journal of Educational Psychology, 1997. **89**(2): p. 369.

122. Fox, K.R., et al., *The effects of exercise on self-perceptions and self-esteem.* Physical activity and psychological well-being, 2000. **13**: p. 81-118.

123. Stathi, A., K.R. Fox, and J. McKenna, *Physical activity and dimensions of subjective well-being in older adults.* Journal of aging and physical activity, 2002. **10**(1): p. 76-92.

124. Bowler, D.E., et al., *A systematic review of evidence for the added benefits to health of exposure to natural environments.* BMC public health, 2010. **10**(1): p. 456.

125. Reynolds, V., *The Green Gym: Evaluation of a Pilot Project in Sonning Common, Oxfordshire*. 1999: Oxford Centre for Health Care Research & Development.

126. Townsend, M., et al. *Healthy Parks Healthy People: the state of the evidence 2015.* . 2015 13/09/2016]; Available from: http://parkweb.vic.gov.au/__data/assets/pdf_file/0003/672582/HPHP_state-of-the-evidence_2015.pdf.

127. Depledge, M.H. and W.J. Bird, *The Blue Gym: health and wellbeing from our coasts*. 2009, Pergamon.

128. Hansmann, R., S.-M. Hug, and K. Seeland, *Restoration and stress relief through physical activities in forests and parks.* Urban Forestry & Urban Greening, 2007. **6**(4): p. 213-225.

129. Herzog, T.R., P. Maguire, and M.B. Nebel, *Assessing the restorative components of environments.* Journal of Environmental Psychology, 2003. **23**(2): p. 159-170.

130. Kaplan, R. and S. Kaplan, *The experience of nature: A psychological perspective*. 1989: CUP Archive.

131. Kaplan, S., *The restorative benefits of nature: Toward an integrative framework.* Journal of environmental psychology, 1995. **15**(3): p. 169-182.

132. Thompson Coon, J., et al., *Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review.* Environmental science & technology, 2011. **45**(5): p. 1761-1772.

133. Barton, J., M. Griffin, and J. Pretty, *Exercise-, nature-and socially interactive-based initiatives improve mood and self-esteem in the clinical population.* Perspectives in public health, 2012. **132**(2): p. 89-96.

134. Stamps, A.E., *Demographic effects in environmental aesthetics: A meta-analysis.* Journal of Planning Literature, 1999. **14**(2): p. 155-175.

135. Hartig, T. and H. Staats, *The need for psychological restoration as a determinant of environmental preferences.* Journal of Environmental Psychology, 2006. **26**(3): p. 215-226.

136. Hug, S.-M., et al., *Restorative qualities of indoor and outdoor exercise settings as predictors of exercise frequency.* Health & place, 2009. **15**(4): p. 971-980.

137. Gladwell, V.F., et al., *The great outdoors: how a green exercise environment can benefit all.* Extreme Physiology & Medicine, 2013. **2**(1): p. 3.

138. Jacobs, J.M., et al., *Going outdoors daily predicts long-term functional and health benefits among ambulatory older people.* Journal of Aging and Health, 2008. **20**(3): p. 259-272.

139. Lauretani, F., et al., *Vitamin D in older population: new roles for this 'classic actor'?* The Aging Male, 2010. **13**(4): p. 215-232.

140. Diabetes Prevention Program Research Group, *Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin.* N Engl j Med, 2002. **2002**(346): p. 393-403.

141. McMahon, S., K.M. Talley, and J.F. Wyman, *Older people's perspectives on fall risk and fall prevention programs: a literature review.* International Journal of Older People Nursing, 2011. **6**(4): p. 289-298.

142. Evron, L., K. Schultz-Larsen, and T. Fristrup, *Barriers to participation in a hospital-based falls assessment clinic programme: an interview study with older people.* Scandinavian Journal of Public Health, 2009.

143. Australian Bureau of Statistics. *3235.0 - Population by Age and Sex, Regions of Australia, 2013*. 2013 28/08/2014 28/05/2015]; Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/3235.0.

144. Meessen, J., et al., *Assessment of mortality risk in elderly patients after proximal femoral fracture.* Orthopedics, 2014. **37**(2): p. e194-e200.

145. Bentler, S.E., et al., *The aftermath of hip fracture: discharge placement, functional status change, and mortality.* American journal of epidemiology, 2009. **170**(10): p. 1290-1299.

146. Sherrington, C., et al., *Exercise to prevent falls in older adults: an updated meta-analysis and best practice recommendations.* New South Wales public health bulletin, 2011. **22**(4): p. 78-83.

147. de Vreede, P.L. and E.C.P.M. Tak. *National report on assessment instruments for physical activity and physical functioning in older people in the Netherlands*. TNO EUNAAPA 2007 28/05/2015]; Available from: http://eunaapa.org/media/dutch_national_report_assessment_instruments.pdf.

148. Moher, D., et al., *CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials.* Journal of clinical epidemiology, 2010. **63**(8): p. e1-e37.

149. Schulz, K.F., D.G. Altman, and D. Moher, *CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials.* BMC medicine, 2010. **8**(1): p. 18.

150. Preference Collaborative Review Group, *Patients' preferences within randomised trials: systematic review and patient level meta-analysis.* BMJ: British Medical Journal, 2008. **337**: p. a1864.

151. Torgerson, D.J., J. Klaber-Moffett, and I.T. Russell, *Patient preferences in randomised trials: threat or opportunity?* Journal of Health Services Research, 1996. **1**(4): p. 194-197.

152. Torgerson, D.J. and B. Sibbald, *Understanding controlled trials. What is a patient preference trial?* BMJ: British Medical Journal, 1998. **316**(7128): p. 360.

153. Hill, K., et al., *A new test of dynamic standing balance for stroke patients: reliability, validity and comparison with health elderly.* Physiotherapy Canada, 1996. **48**: p. 257-262.

154. Shumway-Cook, A., S. Brauer, and M. Woollacott, *Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test.* Physical Therapy, 2000. **80**(9): p. 896-903.

155. Duncan, P.W., et al., *Functional reach: a new clinical measure of balance.* The Journals of Gerontology, 1990. **45**(6): p. M192-197.

156. Anacker, S.L. and R.P. Di Fabio, *Influence of sensory inputs on standing balance in community-dwelling elders with a recent history of falling.* Physical therapy, 1992. **72**(8): p. 575-581.

157. Haines, T., et al., *Development and validation of the balance outcome measure for elder rehabilitation.* Archives of Physical Medicine and Rehabilitation, 2007. **88**(12): p. 1614-1621.

158. Kuys, S.S., et al., *Further validation of the Balance Outcome Measure for Elder Rehabilitation.* Archives of Physical Medicine and Rehabilitation, 2011. **92**(1): p. 101-105.

159. Di Fabio, R. and S. Anacker, *Identifying fallers in community living elders using a clinical test of sensory interaction for balance.* European journal of physical medicine & rehabilitation, 1996. **6**(2): p. 61-66.

160. Cho, B.l., D. Scarpace, and N.B. Alexander, *Tests of Stepping as Indicators of Mobility, Balance, and Fall Risk in Balance‐Impaired Older Adults.* Journal of the American Geriatrics Society, 2004. **52**(7): p. 1168-1173.

161. Podsiadlo, D. and S. Richardson, *The timed" Up & Go": a test of basic functional mobility for frail elderly persons.* Journal of the American geriatrics Society, 1991. **39**(2): p. 142-148.

162. Vereeck, L., et al., *Clinical assessment of balance: normative data, and gender and age effects.* International journal of audiology, 2008. **47**(2): p. 67-75.

163. Tromp, A., et al., *Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly.* Journal of Clinical Epidemiology, 2001. **54**(8): p. 837-844.

164. Sallinen, J., et al., *Hand-Grip Strength Cut Points to Screen Older Persons at Risk for Mobility Limitation.* Journal of the American Geriatrics Society, 2010. **58**(9): p. 1721-1726.

165. Fess, E. and C. Moran, *Clinical assessment recommendation.* American Society of Hand Therapists, 1981.

166. Butland, R.J., et al., *Two-, six-, and 12-minute walking tests in respiratory disease.* British Medical Journal, 1982. **284**(6329): p. 1607-1608.

167. Gijbels, D., B. Eijnde, and P. Feys, *Comparison of the 2-and 6-minute walk test in multiple sclerosis.* Multiple Sclerosis Journal, 2011. **17**(10): p. 1269-1272.

168. Kosak, M. and T. Smith, *Comparison of the 2-, 6-, and 12-minute walk tests in patients with stroke.* Journal of Rehabilitation Research & Development, 2005. **42**(1): p. 103-108.

169. Csuka, M. and D.J. McCarty, *Simple method for measurement of lower extremity muscle strength.* The American Journal of Medicine, 1985. **78**(1): p. 77-81.

170. Tinetti, M.E., *Performance-oriented assessment of mobility problems in elderly patients.* Journal of the American Geriatrics Society, 1986. **34**(2): p. 119-126.

171. Berg, K.O., et al., *Measuring balance in the elderly: validation of an instrument.* Canadian Journal of Public Health, 1992. **83**(2): p. S7-11.

172. Hausdorff, J.M., D.A. Rios, and H.K. Edelberg, *Gait variability and fall risk in community-living older adults: a 1-year prospective study.* Archives of Physical Medicine and Rehabilitation, 2001. **82**(8): p. 1050-1056.

173. Paterson, K., K. Hill, and N. Lythgo, *Stride dynamics, gait variability and prospective falls risk in active community dwelling older women.* Gait & Posture, 2011. **33**(2): p. 251-255.

174. Besser, M.P., et al., *Representation of temporal spatial gait parameters using means in adults without impairment.* Gait Posture, 1999. **9**(2): p. 113.

175. Hollman, J.H., et al., *Number of strides required for reliable measurements of pace, rhythm and variability parameters of gait during normal and dual task walking in older individuals.* Gait & posture, 2010. **32**(1): p. 23-28.

176. Ware Jr, J.E., M. Kosinski, and S.D. Keller, *A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity.* Medical care, 1996. **34**(3): p. 220-233.

177. Jakobsson, U., *Using the 12-item Short Form health survey (SF-12) to measure quality of life among older people.* Aging clinical and experimental research, 2007. **19**(6): p. 457-464.

178. Delbaere, K., K. Hauer, and S.R. Lord, *Evaluation Of The Incidental And Planned Activity Questionnaire (IPAQ) For Older People.* Br J Sports Med, 2009. **44**(14): p. 1029-34.

179. Levinger, P., et al., *Lower limb proprioception deficits persist following knee replacement surgery despite improvements in knee extension strength.* Knee Surgery, Sports Traumatology, Arthroscopy, 2012. **20**(6): p. 1097-1103.

180. Levinger, P., et al., *Physiological risk factors for falls in people with knee osteoarthritis before and early after knee replacement surgery.* Knee Surgery, Sports Traumatology, Arthroscopy, 2011. **19**(7): p. 1082-1089.

181. Mathew, R.S., et al., *Depressive symptoms and quality of life in people with age‐related macular degeneration.* Ophthalmic and Physiological Optics, 2011. **31**(4): p. 375-380.

182. Kempen, G.I., et al., *The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling.* Age Ageing, 2008. **37**(1): p. 45-50.

183. House, J.S., C. Robbins, and H.L. Metzner, *The association of social relationships and activities with mortality: prospective evidence from the Tecumseh Community Health Study*. American journal of epidemiology, 1982. **116**(1): p. 123-140.

184. Miller, R.R., et al., *Repeat falls and the recovery of social participation in the year post-hip fracture.* Age and Ageing, 2009. **38**(5): p. 570-575.

185. Marsh, H.W., A.J. Martin, and S. Jackson, *Introducing a short version of the Physical Self Description Questionnaire: New strategies, short-form evaluative criteria, and applications of factor analyses.* Journal of sport & exercise psychology, 2010. **32**(4): p. 438-482.

186. Braun, V. and V. Clarke, *Using thematic analysis in psychology.* Qualitative research in psychology, 2006. **3**(2): p. 77-101.

187. Clarke, V. and V. Braun, *Thematic analysis*, in *Encyclopedia of critical psychology*. 2014, Springer. p. 1947-1952.

188. Borg, G.A., *Psychophysical bases of perceived exertion.* Medicine & Science in Sports & Exercise, 1982. **14**(5): p. 377-381.

189. Australian Bureau of Statistics. *Australian Health Survey: Physical Activity, 2011-12*. 2013 19/07/2013 28/05/2015]; Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4364.0.55.004Main+Features12011-12?OpenDocument.

190. Medical Advisory Secretariat, *Social isolation in community-dwelling seniors: an evidence-based analysis.* Ontario Health Technology Assessment Series, 2008. **8**(5): p. 1-49.

191. Leitner, M.J. and S.F. Leitner, *Leisure in later life*. Fourth ed. 2012, Urbana, IL: Sagamore Publishing.

192. Touvier, M., et al., *Changes in leisure-time physical activity and sedentary behaviour at retirement: a prospective study in middle-aged French subjects.* Int J Behav Nutr Phys Act, 2010. **7**(14.10): p. 1186.

193. Teas, J., et al., *Walking outside improves mood for healthy postmenopausal women.* Clinical Medicine: Oncology, 2007. **1**: p. 35-43.

194. Merrill, R.M., et al., *Climate conditions and physical activity in the United States.* American Journal of Health Behavior, 2005. **29**(4): p. 371-381.

195. McInnes, E. and L. Askie, *Evidence review on older people's views and experiences of falls prevention strategies.* Worldviews on Evidence-Based Nursing, 2004. **1**(1): p. 20-37.

196. Mody, L., et al., *Recruitment and retention of older adults in aging research.* Journal of the American Geriatrics Society, 2008. **56**(12): p. 2340-2348.

197. King, M., et al., *Impact of participant and physician intervention preferences on randomized trials: a systematic review.* Jama, 2005. **293**(9): p. 1089-1099.

198. Yardley, L., et al., *How likely are older people to take up different falls prevention activities?* Preventive medicine, 2008. **47**(5): p. 554-558.

199. Sales, M.P., et al., *A novel dynamic exercise initiative for older people to improve health and well-being: study protocol for a randomised controlled trial.* BMC geriatrics, 2015. **15**(1): p. 68.

200. Springer, B.A., et al., *Normative values for the unipedal stance test with eyes open and closed.* Journal of Geriatric Physical Therapy, 2007. **30**(1): p. 8-15.

201. Kempen, G.I., et al., *The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling.* Age and Ageing, 2008. **37**(1): p. 45-50.

202. Cohen, J., *Statistical power analysis for the behavioral sciences* 2ed. 1988, Hillside, NJ: Lawrence Erlbaum Associates.

203. Whitbourne, S.K., *The aging body: Physiological changes and psychological consequences*. 2012: Springer Science & Business Media.

204. Unnebrink, K. and J. Windeler, *Intention‐to‐treat: methods for dealing with missing values in clinical trials of progressively deteriorating diseases.* Statistics in medicine, 2001. **20**(24): p. 3931-3946.

205. Simons-Morton, D.G., E. Obarzanek, and J.A. Cutler, *Obesity research—limitations of methods, measurements, and medications.* Jama, 2006. **295**(7): p. 826-828.

206. Baron, G., et al., *Violation of the intent‐to‐treat principle and rate of missing data in superiority trials assessing structural outcomes in rheumatic diseases.* Arthritis & Rheumatism, 2005. **52**(6): p. 1858-1865.

207. Armijo-Olivo, S., S. Warren, and D. Magee, *Intention to treat analysis, compliance, drop-outs and how to deal with missing data in clinical research: a review*. Physical Therapy Reviews, 2009. **14**(1): p. 36-49.

208. Taaffe, D.R., et al., *Once‐weekly resistance exercise improves muscle strength and neuromuscular performance in older adults.* Journal of the American Geriatrics Society, 1999. **47**(10): p. 1208-1214.

209. Howe, T., et al., *Exercise for improving balance in older people (Review).* Cochrane Database Syst Rev, 2011. **9**(11): p. CD004963.

210. Seidel, D., C. Brayne, and C. Jagger, *Limitations in physical functioning among older people as a predictor of subsequent disability in instrumental activities of daily living.* Age and ageing, 2011: p. afr054.

211. Lee, L.-L., A. Arthur, and M. Avis, *Using self-efficacy theory to develop interventions that help older people overcome psychological barriers to physical activity: a discussion paper.* International journal of nursing studies, 2008. **45**(11): p. 1690-1699.

212. Tucker, G., R. Adams, and D. Wilson, *New Australian population scoring coefficients for the old version of the SF-36 and SF-12 health status questionnaires.* Quality of Life Research, 2010. **19**(7): p. 1069-1076.

213. Brassington, G.S., et al., *Intervention-related cognitive versus social mediators of exercise adherence in the elderly.* American journal of preventive medicine, 2002. **23**(2): p. 80-86.

214. Opdenacker, J., C. Delecluse, and F. Boen, *The Longitudinal Effects of a Lifestyle Physical Activity Intervention and a Structured Exercise Intervention on Physical Self-Perceptions and Self-Esteem in Older Adults.* Journal of Sport & Exercise Psychology, 2009. **31**(6): p. 743-760.

215. Nyman, S.R. and C.R. Victor, *Older people's participation in and engagement with falls prevention interventions in community settings: an augment to the Cochrane systematic review.* Age and ageing, 2012. **41**(1): p. 16-23.

216. Stevens, M., et al., *Preventing falls in older people: outcome evaluation of a randomized controlled trial.* Journal of the American Geriatrics Society, 2001. **49**(11): p. 1448-1455.

217. Day, L., et al., *Randomised factorial trial of falls prevention among older people living in their own homes.* Bmj, 2002. **325(**7356): p. 128.

218. Sales, M., et al., *A Novel Exercise Initiative for Seniors to Improve Balance and Physical Function.* Journal of Aging and Health, 2016.

219. O'Cathain, A., et al., *What can qualitative research do for randomised controlled trials? A systematic mapping review.* BMJ open, 2013. **3**(6): p. e002889.

220. McAuley, E., et al., *Predicting long-term maintenance of physical activity in older adults.* Preventive medicine, 2003. **37**(2): p. 110-118.

221. Faber, M.J., et al., *Effects of exercise programs on falls and mobility in frail and pre-frail older adults: a multicenter randomized controlled trial.* Archives of physical medicine and rehabilitation, 2006. **87**(7): p. 885-896.

222. Korpelainen, R., et al., *Effect of impact exercise on bone mineral density in elderly women with low BMD: a population-based randomized controlled 30-month intervention.* Osteoporosis International, 2006. **17**(1): p. 109-118.

223. Liu-Ambrose, T., et al., *Resistance and agility training reduce fall risk in women aged 75 to 85 with low bone mass: A 6-month randomized, controlled trial.* Journal of the American Geriatrics Society, 2004. **52**(5): p. 657-665.

224. Polman, R.C., E. Borkoles, and F. Ling, *Physical activity behavior in the tropics*, in *Science of Sport, Exercise and Physical Activity in the Tropics*, A. Edwards and A. Leicht, Editors. 2014, NOVA Scientific: New York. p. 123-136.

225. De Bloom, J., U. Kinnunen, and K. Korpela, *Exposure to nature versus relaxation during lunch breaks and recovery from work: development and design of an intervention study to improve workers' health, well-being, work performance and creativity*. BMC public health, 2014. **14**(1): p. 1.

226. Chow, H.-W., *Outdoor fitness equipment in parks: a qualitative study from older adults' perceptions.* BMC public health, 2013. **13**(1): p. 1.

227. Mowen, A., et al., *The role of park proximity and social support in shaping park visitation, physical activity, and perceived health among older adults.* Journal of physical activity & health, 2007. **4**(2): p. 167.

228. Parra, D.C., et al., *Built environment characteristics and perceived active park use among older adults: results from a multilevel study in Bogotá.* Health & Place, 2010. **16**(6): p. 1174-1181.

229. Fultz, N.H., et al., *Burden of stress urinary incontinence for community-dwelling women.* American journal of obstetrics and gynecology, 2003. **189**(5): p. 1275-1282.

230. Kaplan, M.S., et al., *Demographic and psychosocial correlates of physical activity in late life.* American journal of preventive medicine, 2001. **21**(4): p. 306-312.

231. Kilpatrick, M., E. Hebert, and J. Bartholomew, *College students' motivation for physical activity: differentiating men's and women's motives for sport participation and exercise.* Journal of American college health, 2005. **54**(2): p. 87-94.

232. Netz, Y., et al., *Physical activity and psychological well-being in advanced age: a meta-analysis of intervention studies.* Psychology and aging, 2005. **20**(2): p. 272.

233. Barbour, K.A. and J.A. Blumenthal, *Exercise training and depression in older adults.* Neurobiology of aging, 2005. **26**(1): p. 119-123.

234. Sonstroem, R.J. and W.P. Morgan, *Exercise and self-esteem: rationale and model.* Medicine & Science in Sports & Exercise, 1989. **21**(3): p. 329-337.

235. Haugen, T., R. Säfvenbom, and Y. Ommundsen, *Physical activity and global self-worth: The role of physical self-esteem indices and gender.* Mental Health and Physical Activity, 2011. **4**(2): p. 49-56.

236. Savikko, N., et al., *Predictors and subjective causes of loneliness in an aged population.* Archives of gerontology and geriatrics, 2005. **41**(3): p. 223-233.

237. Grenade, L. and D. Boldy, *Social isolation and loneliness among older people: issues and future challenges in community and residential settings.* Australian Health Review, 2008. **32**(3): p. 468-478.

238. Marsh, H.W., et al., *Physical Self Description Questionnaire: psychometric properties and multitrait-multimethod analysis of relations to existing instruments.* Journal of Sport & Exercise Psychology, 1994. **16**: p. 270-305.

239. Byrne, B., *Measuring self-concept across the lifespan: Methodology and instrumentation for research and practice.* Washington, DC: American Psychological Association, 1996.

240. Marsh, H.W., I.T. Marco, and F.H. Apçý, *Cross-cultural validity of the Physical Self-Description Questionnaire: Comparison of factor structures in Australia, Spain, and Turkey.* Research Quarterly for Exercise and Sport, 2002. **73**(3): p. 257-270.

241. Windle, G., et al., *Public health interventions to promote mental well-being in people aged 65 and over: systematic review of effectiveness and cost-effectiveness.* International Journal of Older People Nursing, 2008. **5**(1): p. 16-24.

242. Halle, D., *America's Working Man: Work, Home, and Politics among Blue Collar Property Owners*. 1984: University of Chicago Press.

243. Fox, K. and J. Harris, *Promoting physical activity through schools.* Perspectives on health and exercise, 2003: p. 181-202.

244. Jones, R.J.A., R.C.J. Polman, and D.M. Peters, *Physical self-perceptions of adolescents in Years 8, 9 and 10 in independent schools, state comprehensive schools and specialist sport colleges in England.* Physical Education and Sport Pedagogy, 2009. **14**(2): p. 109-124.

245. Marsh, H.W. and R.S. Redmayne, *A multidimensional physical self-concept and its relations to multiple components of physical fitness.* Journal of Sport and Exercise Psychology, 1994. **16**: p. 43-43.

246. Jasnoski, M.L., et al., *Exercise, changes in aerobic capacity, and changes in self-perceptions: An experimental investigation.* Journal of Research in Personality, 1981. **15**(4): p. 460-466.

247. Moore, J.B., et al., *Physical self-esteem in older adults: A test of the indirect effect of physical activity.* Sport, Exercise, and Performance Psychology, 2012. **1**(4): p. 231-241.

248. Brewer, W.A. and S.L. Olson, *Are there relationships between perceived and actual measures of physical fitness and health for healthy young women?* Comprehensive Psychology, 2015. **4**(1).

249. Hughes, J.R., *Psychological effects of habitual aerobic exercise: A critical review.* Preventive medicine, 1984. **13**(1): p. 66-78.

250. Hayes, V., et al., *The SF-36 health survey questionnaire: is it suitable for use with older adults?* Age and Ageing, 1995. **24**(2): p. 120-125.

251. Fox, K.R., *Self-esteem, self-perceptions and exercise.* International Journal of Sport Psychology, 2000. **31**(2): p. 228-240.

252. Gothe, N.P., et al., *Trajectories of change in self-esteem in older adults: exercise intervention effects.* Journal of Behavioral Medicine, 2011. **34**(4): p. 298-306.

253. McAuley, E., et al., *Physical activity, self-efficacy, and self-esteem: Longitudinal relationships in older adults.* The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 2005. **60**(5): p. P268-P275.

254. Amesberger, G., et al., *Physical self-concept and physical fitness in elderly individuals.* Scandinavian journal of medicine & science in sports, 2011. **21**(s1): p. 83-90.

255. Yeom, H.A., J. Fleury, and C. Keller, *Risk Factors for Mobility Limitation in Community-Dwelling Older Adults: A Social Ecological Perspective.* Geriatric Nursing, 2008. **29**(2): p. 133-140.

256. Chiao, C., L.-J. Weng, and A.L. Botticello, *Social participation reduces depressive symptoms among older adults: an 18-year longitudinal analysis in Taiwan.* BMC public health, 2011. **11**(1): p. 292.

257. Ajzen, I. and M. Fishbein, *Belief, attitude, intention and behavior: An introduction to theory and research*. 1975, Reading, MA: Addison-Wesley.

258. Jensen, M.P., et al., *Patient beliefs predict patient functioning: further support for a cognitive-behavioural model of chronic pain.* Pain, 1999. **81**(1): p. 95-104.

259. Rejeski, W.J., *Dose–response issues from a psychosocial perspective.* 1994.

260. Rejeski, W.J. and S.L. Mihalko, *Physical Activity and Quality of Life in Older Adults.* The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 2001. **56**(suppl 2): p. 23-35.

261. Scully, D., et al., *Physical exercise and psychological well being: a critical review.* British journal of sports medicine, 1998. **32**(2): p. 111-120.

262. Haskell, W.L., et al., *Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association.* Circulation, 2007. **116**(9): p. 1081.

263. King, A.C., W.J. Rejeski, and D.M. Buchner, *Physical activity interventions targeting older adults: a critical review and recommendations.* American journal of preventive medicine, 1998. **15**(4): p. 316-333.

264. Dishman, R.K., *The problem of exercise adherence: Fighting sloth in nations with market economies.* Quest, 2001. **53**(3): p. 279-294.

265. Müller-Riemenschneider, F., et al., *Long-term effectiveness of interventions promoting physical activity: a systematic review.* Preventive medicine, 2008. **47**(4): p. 354-368.

266. King, M.B., et al., *The Performance Enhancement Project: improving physical performance in older persons.* Archives of Physical Medicine and Rehabilitation, 2002. **83**(8): p. 1060-1069.

267. Li, F., et al., *Exercise and Fall Prevention: Narrowing the Research‐to‐Practice Gap and Enhancing Integration of Clinical and Community Practice.* Journal of the American Geriatrics Society, 2016. **64**(2): p. 425-431.

268. Fjeldsoe, B., et al., *Systematic review of maintenance of behavior change following physical activity and dietary interventions.* Health Psychology, 2011. **30**(1): p. 99.

269. Delbaere, K., K. Hauer, and S.R. Lord, *Evaluation of the incidental and planned activity questionnaire (IPEQ) for older people.* Br J Sports Med, 2010. **44**(14): p. 1029-34.

270. Forkan, R., et al., *Exercise adherence following physical therapy intervention in older adults with impaired balance.* Physical Therapy, 2006. **86**(3): p. 401-410.

271. Hróbjartsson, A., T.J. Kaptchuk, and F.G. Miller, *Placebo effect studies are susceptible to response bias and to other types of biases.* Journal of clinical epidemiology, 2011. **64**(11): p. 1223-1229.

272. Waters, L., et al., *Control Group Improvements in Physical Activity Intervention Trials and Possible Explanatory Factors: A Systematic Review.* Journal of Physical Activity & Health, 2012. **9**(6): p. 884-895.

273. Prochaska, J.O., *Transtheoretical model of behavior change*, in *Encyclopedia of behavioral medicine*. 2013, Springer. p. 1997-2000.

274. Bandura, A., *Social foundations of thought and action: A social cognitive theory*. 1986, Englewood Cliffs, NJ: Prentice-Hall, Inc.

275. Bandura, A., *Self-efficacy: toward a unifying theory of behavioral change.* Psychological review, 1977. **84**(2): p. 191.

276. Prince, S.A., et al., *A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review.* International Journal of Behavioral Nutrition and Physical Activity, 2008. **5**(1): p. 1.

277. James, K., et al., *Falls and fall prevention in the elderly: the Jamaican perspective.* West Indian Medical Journal, 2007. **56**(6): p. 534-539.

278. Thibaud, M., et al., *Impact of physical activity and sedentary behaviour on fall risks in older people: a systematic review and meta-analysis of observational studies.* European Review of Aging and Physical Activity, 2012. **9**(1): p. 5-15.

279. Sterling, D.A., J.A. O'connor, and J. Bonadies, *Geriatric falls: injury severity is high and disproportionate to mechanism.* Journal of Trauma and Acute Care Surgery, 2001. **50**(1): p. 116-119.

280. Chase, C.A., et al., *Systematic review of the effect of home modification and fall prevention programs on falls and the performance of community-dwelling older adults.* American Journal of Occupational Therapy, 2012. **66**(3): p. 284-291.

281. Newson, R.S. and E.B. Kemps, *Cardiorespiratory fitness as a predictor of successful cognitive ageing.* Journal of Clinical and Experimental Neuropsychology, 2006. **28**(6): p. 949-967.

282. World Health Organization, *The Heidelberg guidelines for promoting physical activity among older persons-Guidelines Series for Healthy Ageing I*. 1996, Heidelberg.

283. Stiggelbout, M., et al., *Predicting older adults' maintenance in exercise participation using an integrated social psychological model.* Health Education Research, 2006. **21**(1): p. 1-14.

284. Kolt, G.S., R.P. Driver, and L.C. Giles, *Why older Australians participate in exercise and sport.* Journal of Aging and Physical Activity, 2004. **12**(2): p. 185-198.

285. Shiu-Thornton, S., et al., *Older adult perspectives on physical activity and exercise: voices from multiple cultures.* Preventing Chronic Disease, 2004. **1**: p. A09.

286. Luppa, M., et al., *Age-and gender-specific prevalence of depression in latest-life–systematic review and meta-analysis.* Journal of affective disorders, 2012. **136**(3): p. 212-221.

287. Fiske, A., J.L. Wetherell, and M. Gatz, *Depression in older adults.* Annual review of clinical psychology, 2009. **5**: p. 363-389.

288. Holt-Lunstad, J., T.B. Smith, and J.B. Layton, *Social relationships and mortality risk: a meta-analytic review.* PLoS Med, 2010. **7**(7): p. e1000316.

289. Cohen, S., *Social relationships and health.* American psychologist, 2004. **59**(8): p. 676.

290. Umberson, D., *Gender, marital status and the social control of health behavior.* Social science & medicine, 1992. **34**(8): p. 907-917.

291. Umberson, D., R. Crosnoe, and C. Reczek, *Social Relationships and Health Behavior Across Life Course.* Annual review of sociology, 2010. **36**: p. 139-157.

292. Barnes, D.E., et al., *The Mental Activity and eXercise (MAX) trial: a randomized controlled trial to enhance cognitive function in older adults.* JAMA internal medicine, 2013. **173**(9): p. 797-804.

293. Finch, H. and G. Britain, *Physical Activity" at Our Age": Qualitative Research Among People Over the Age of 50*. 1997: Health Education Authority London.

294. Spirduso, W.W. and D.L. Cronin, *Exercise dose–response effects on quality of life and independent living in older adults.* Medicine & science in sports & exercise, 2001.

295. Holick, M.F., *Vitamin D deficiency in 2010: health benefits of vitamin D and sunlight: a D-bate.* Nature Reviews Endocrinology, 2011. **7**(2): p. 73-75.

296. Petursdottir, U., S.A. Arnadottir, and S. Halldorsdottir, *Facilitators and barriers to exercising among people with osteoarthritis: a phenomenological study.* Physical Therapy, 2010. **90**(7): p. 1014.

297. Andrade, H., M.-J. Alcoforado, and S. Oliveira, *Perception of temperature and wind by users of public outdoor spaces: relationships with weather parameters and personal characteristics.* International journal of biometeorology, 2011. **55**(5): p. 665-680.

298. Shubert, T.E., et al., *Complexities of fall prevention in clinical settings: A commentary.* The Gerontologist, 2013: p. gnt079.

299. Laing, S.S., et al., *Fall prevention knowledge, attitude, and practices of community stakeholders and older adults.* Journal of aging research, 2011. **2011**.

300. Areán, P.A. and D. Gallagher-Thompson, *Issues and recommendations for the recruitment and retention of older ethnic minority adults into clinical research.* Journal of Consulting and Clinical Psychology, 1996. **64**(5): p. 875.

301. LeVine, E.S. and A.M. Padilla, *Crossing cultures in therapy: Pluralistic counseling for the Hispanic*. 1980: Brooks/Cole Pub Co.

302. Newson, R.S. and E.B. Kemps, *Factors that promote and prevent exercise engagement in older adults.* Journal of aging and health, 2007. **19**(3): p. 470-481.

303. Oettingen, G. and P.M. Gollwitzer, *Goal setting and goal striving*, in *Blackwell handbook of social psychology: Intraindividual processes*, A. Tesser and N. Schwarz, Editors. 2001, Blackwell: Oxford, England. p. 329-348.

304. Green, L., L. Oades, and A. Grant, *Cognitive-behavioral, solution-focused life coaching: Enhancing goal striving, well-being, and hope.* The Journal of Positive Psychology, 2006. **1**(3): p. 142-149.

305. McAuley, E., et al., *Self-regulatory processes and exercise adherence in older adults: executive function and self-efficacy effects.* American journal of preventive medicine, 2011. **41**(3): p. 284-290.

306. Peel, C., et al., *A survey of fall prevention knowledge and practice patterns in home health physical therapists.* Journal of geriatric physical therapy, 2008. **31**(2): p. 64-70.

307. Joseph, A., et al., *Presence and visibility of outdoor and indoor physical activity features and participation in physical activity among older adults in retirement communities.* Journal of Housing for the Elderly, 2006. **19**(3-4): p. 141-165.

308. Australian Bureau of Statistics. *3235.0 - Population by Age and Sex, Regions of Australia, 2015*. 2016 18/08/2016 03/01/2017]; Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/mf/3235.0.

309. Lindström, D., et al., *Disappointment and drop-out rate after being allocated to control group in a smoking cessation trial.* Contemporary clinical trials, 2010. **31**(1): p. 22-26.

310. Neumann, M., et al., *Can patient–provider interaction increase the effectiveness of medical treatment or even substitute it?—An exploration on why and how to study the specific effect of the provider*. Patient education and counseling, 2010. **80**(3): p. 307-314.

311. Egbert, L.D., et al., *Reduction of postoperative pain by encouragement and instruction of patients: a study of doctor-patient rapport.* New England Journal of Medicine, 1964. **270**(16): p. 825-827.

312. Relton, C., et al., *Rethinking pragmatic randomised controlled trials: introducing the "cohort multiple randomised controlled trial" design.* Bmj, 2010. **340**: p. c1066.

313. Lindquist, R., et al., *Design of control-group conditions in clinical trials of behavioral interventions.* Journal of Nursing Scholarship, 2007. **39**(3): p. 214-221.

314. Cunningham, J.A., K. Kypri, and J. McCambridge, *Exploratory randomized controlled trial evaluating the impact of a waiting list control design.* BMC medical research methodology, 2013. **13**(1): p. 150.

315. Hart, T. and E. Bagiella, *Design and implementation of clinical trials in rehabilitation research.* Archives of physical medicine and rehabilitation, 2012. **93**(8): p. S117-S126.

316. Hart, T., J.R. Fann, and T.A. Novack, *The dilemma of the control condition in experience-based cognitive and behavioural treatment research.* Neuropsychological Rehabilitation, 2008. **18**(1): p. 1-21.

Appendix 1 - Informed Consent Form

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

INFORMATION TO PARTICIPANTS:

We would like to invite you to be part of a study titled "**Active ageing: A novel dynamic exercise initiative for older people to improve health and well-being**".

The main objectives of this study are:

(1) To evaluate the efficacy of an exercise intervention using an exercise park specifically designed for older people in reducing the risk of falls and improving strength and balance.
(2) To evaluate what other benefits, including quality of life, can be achieved by using this specific exercise park on a regular basis.

CERTIFICATION BY SUBJECT:

I, ____

of ____

certify that I am voluntarily giving my consent to participate in the study: Active ageing: A novel dynamic exercise initiative for older people to improve health and well-being" being conducted at Victoria University by Mrs. Myrla Sales from the Institute of Sport, Exercise and Active Living (ISEAL) under the supervision of Professor Remco Polman and Dr. Pazit Levinger as part of Mrs. Sales PhD Research.

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:

Name of researcher: ____

And that I freely consent to participation involving the below mentioned procedures:

- Muscle Strength Tests (at VU or St Bernadette's Community Respite House).
- Functional and balance tasks (at VU or St Bernadette's Community Respite House).
- Questionnaires (at VU or St Bernadette's Community Respite House).

I certify that I was given details about the short exit interview which I may be asked to participate in if I'm allocated to exercise intervention group. The researcher has explained me the purpose of this interview, how and when the interview will be carried out and how the data collected during this interview will be used and stored. I was also informed that my participation in this interview is voluntary and I can stop my participation at any time.

I certify that I have 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:

Mrs. Myrla Sales

Phone: 0432 715 653 or myrla.reissales@live.vu.edu.au

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 2 - Information Sheet to Participants Involved in Research

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

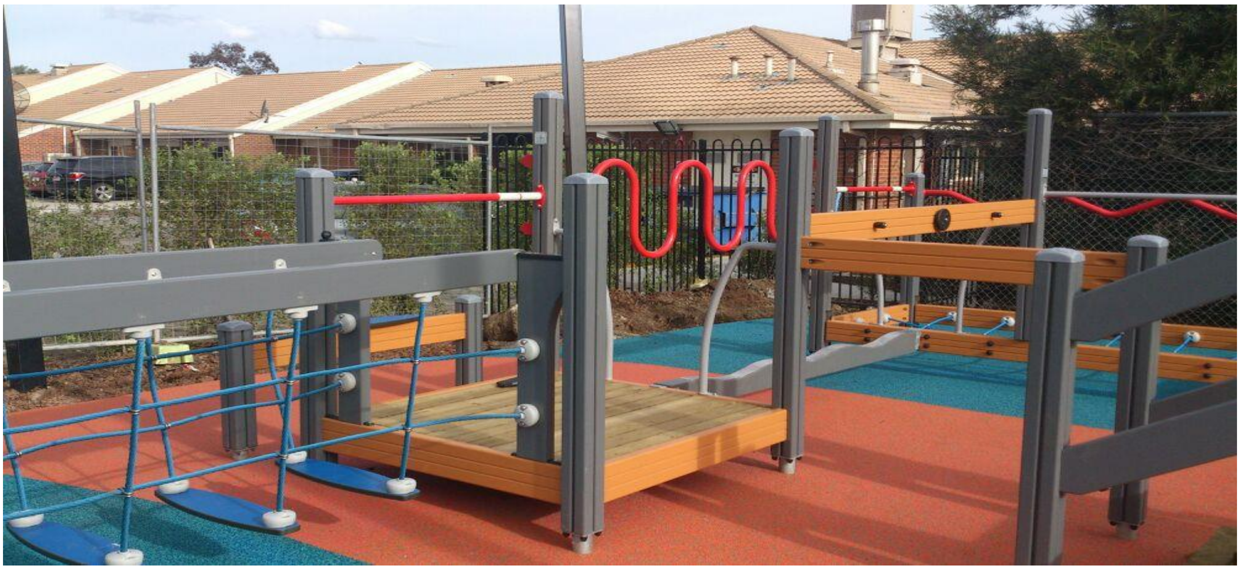
You are invited to participate

You are invited to participate in a research project entitled "**Active ageing: A novel dynamic exercise initiative for older people to improve health and well-being**".

This project is being conducted by Mrs. Myrla Sales a PhD student, under the supervision of Professor Remco Polman and Dr. Pazit Levinger from Victoria University and in partnership with Gateway Social Support Options and Catholic Homes. This project is part of Mrs. Myrla Sales PhD research project and has been partly funded by Gandel Philanthropy.

Project explanation

Falls are a leading cause of disability among older adults. About one third of people aged 65 years or older falls at least once a year. Exercise programmes have been shown to be effective in reducing the risk of falling and the rate of falls because they can improve muscle strength, flexibility and balance. However, older people do not regularly follow to an exercise program intervention. In this project, we would like to introduce a new exercise program that uses an exercise park designed for older people as a way of improving strength and balance. The aim of this study is to investigate if this exercise park program can be effective in improving strength, balance and quality of life in older people aging 60 years and over. Also, this study will evaluate the efficacy of such exercise park program in reducing the risk of falls and evaluate what other benefits, such as social participation and physical self-perception, can be achieved by using this specific exercise park program.



What is an exercise park specifically designed for older people?

An exercise park specifically designed for older people is an outdoor fitness equipment with a purpose of encouraging senior citizens to be active through outdoor exercise/physical fitness (see illustration above). The exercise park equipment includes several stations that incorporate activities to maintain mobility, strength, balance and coordination. For safety reasons, the area around the exercise park is fenced (coded and the access is restricted to authorized personnel only) and shaded. Surfaces are covered with a special cushioned and non-slippery rubber.

Who can participate in the study?

People who are between 60 and 90 years old that are generally active and live independently in the community (e.g. doing their own shopping, dressing themselves) are invited to take part in this study. Therefore, you are invited to take part in the study if you (1) have had at least one fall in the last 12 months or you are concerned you might have a fall and (2) use no more than a single point stick for regular outdoors walking.

You will not be permitted to participate in the study if you have:

- Any symptomatic lung or cardiovascular diseases such as chronic obstructive airways disease and or congestive heart failure;
- A pre-existing neurological or orthopaedic condition affecting walking or mobility;
- A neurological condition that affects lower limb strength (e.g.: stroke, polio);
- Any of the following foot conditions: partial foot amputation or ulceration or foot fractures,
- Any musculoskeletal conditions which may affect the ambulation (e.g.: rheumatoid arthritis, gout).

If you have a heart disease or other cardiovascular disease, you will be asked to provide a medical clearance prior to participation.

What will I be asked to do?

In this study 2 groups will be involved: (1) an intervention group and (2) a control group. This study is a randomised controlled trial which means that you may be allocated by random (by chance alone like tossing a coin) to one of these groups. Participants from both groups will be required to attend Victoria University Footscray Campus for 3 times. In these 3 visits you will be asked to complete a series of functional, physiological and biomechanical tests which will take approximately 2 hours per visit. Attending the 1st visit will occur after you have been recruited to the study while the other 2 visits will occur 18 weeks after your initial visit and then again 2 months later. You will know if you have been allocated to the control group or the intervention group after the initial assessment at the 1st visit.

If you are allocated to the intervention group you will be asked to attend the St Bernadette's Community Respite House in Sunshine North for 2-3 visits per week for the duration of 18 weeks. If you are allocated to the control group you will continue with your normal daily activities for the same period.

Assessments – to be completed at the first visit, 18 weeks after the first visit and 2 months after the 2nd visit. We would like you to complete a series of functional, physiological and biomechanical tests. Those tests will be conducted at Victoria University Footscray Park Campus. The tests will take approximately 2 hours to complete.

You will be asked to perform the following assessments:

- Muscle Strength Tests;
- Functional and Balance Tests;
- Assessment of your walking;
- Questionnaires.

<u>Intervention Group – Exercise Park Program</u> - The exercise intervention group will be using the exercise park over a period of 18 weeks (2-3 times per week for 1 to 1.5-hours duration each session). The exercises aim to improve upper limb and lower limb strength, balance and coordination, upper body mobility and fine motor skills as well

as improve your flexibility. Participation in the exercise program will be in small groups of 6-8 people in each session and will be supervised at all times by qualified staff members. You will have an orientation session before you start so you can familiarise yourself with the equipment.

Control Group - if you have been allocated to be in the control group you will be asked to continue with your normal daily activities for the same period. You will be offered complementary social activities every 2 weeks for 1.5-2 hours (9 meetings over a period of 18 weeks). These activities will be held at Gateway Social Support Options' Main Building (Spotswood) or at the Maidstone Community Centre or at Victoria University (Footscray Park Campus) and will include various social games such as cards, checkers, chess, board games, etc. In addition, you will receive a booklet produced by the Australian Government entitled "Falls can be prevented! A guide to preventing falls for older people". This booklet will provide you with some information about risk factors for falls and a general guide to prevent falls.

Short Exit Interview – Participants in the exercise intervention group may be asked to participate in a short exit interview which will be carried out after you have concluded the exercise intervention period (18 weeks). This interview will be carried out just prior your first follow-up assessment (on the same day). The purpose of this interview is to assess your perception of this exercise program and/or your overall experience with the project. Based on this interview, we will be able to identify elements which need improvement in the future and the main issues we need to address and overcome in future trials. This interview will take around 15-20 minutes and all information you provide will be recorded using a digital voice recorder. You will be asked questions such as "As a result of your participating in the program, have you noticed any changes to your daily life?", "What could you tell me about your overall experience in participating in this program? Was it good or bad?", etc. Your participation in this interview is voluntary and you can stop at any time.

Falls and Physical Activity Calendar – if you are part of the control group or the intervention group you will be provided with monthly calendars and will be asked to keep a record of any falls experienced for a period of 12 months since your initial assessment (visit 1). We will also ask you to record any physical activity you do in this monthly calendar such as any exercise classes that you take or any walking activity you do.

What will I gain from participating?

The exercise program is designed to be an enjoyable and playful activity for individual participants. This experience can also motivate participants to initiate and keep themselves engaged in some kind of physical activity. We cannot guarantee or promise that you will receive any benefits from this research; however, possible benefits for participants from the intervention group may include improve strength and balance.

Participants from both groups will be given feedback of their possible risk of falls as well as their muscle strength and balance measures. Also, a final report about the project findings will be available at the completion of the project for you by request. The exercise park used in this project will remain in the site after the completion of this study. Arrangements and further training on the utilisation of this exercise park will be provided to Catholic Homes/Gateway Social Support Options staff if they wish to continue with the provision of this service to the community. Participants allocated to the control group will be notified if this opportunity arises.

How will the information I give be used?

The information will be used to assess the effectiveness of the exercise park program as a mode of exercise for older people in reducing falls risk and improving quality of life. Any information obtained in connection with this research project that can identify you will remain confidential; your information will be de-identified and will only be used for research purposes. It will only be disclosed with your permission, except as required by law. All information collected, including any written transcripts of interviews, will be stored securely in a locked filing cabinet in the College of Sport and Exercise Science at Victoria University. Your information, including any audio files from the interviews, will also be stored on a password-protected computer database and will be only accessible to Mrs. Myrla Sales and her supervisors. We will keep the information for fifteen years following the completion of the project. After this time, we will destroy the information by shredding documents and/or deleting computer files.

Data that will be collected will be used in scientific publications and/or presentations, information will be provided in such a way that you cannot be identified, except with your permission. The data will be reported as average of the entire group. Moreover, the data collected in this study will be used for a PhD thesis of Mrs. Sales as part of her PhD degree.

What are the potential risks of participating in this project?

There are minimal physical, psychological and social risks associated with this study. This is due to it being practical in nature and the participants taking part in small groups when using this novel exercise park.

Although the physical risks associated with this study are not expected to be higher than the risk of performing daily activities, you may experience some muscle soreness, mild pain and discomfort during physical tests or after using the exercise park.

The exercise session for the intervention group will be tailored to each participant's capacity, i.e., the intensity and volume of exercises prescribed is in conformance with each participant's actual conditioning level. In doing this, the muscle soreness, pain and discomfort will be minimised. Another possible risks and inconveniences, whilst remote, may also include muscle strain and the possibility of having a fall while performing the exercise. However, you will be supervised at all times by trained staff to minimise or eliminate these possible risks. In addition, safety checks will be carried out on all equipment used to make sure it is not harmful to any extent to the participants.

A potential psychological/social risk is if you feel embarrassed for being exercising in the presence of other people. You will be provided with counselling if this requires attention.

Fear of falling is a common problem in older people. Some participants may have concerns associated with having a fall which can prevent them from performing certain activities. In such circumstances you will be introduced to alternative activities/exercises where they feel comfortable to perform.

How will this project be conducted?

Prior to enrolment in the study, you will be asked few questions about general health which will enable the research team to determine if you are eligible to participate in the study. If you are eligible to take part in the study, the research team will organise a time to meet you at Victoria University Footscray Campus Park or at the St Bernadette's Community Respite House. The following assessments will be performed at this day:

Functional, physiological and biomechanical tests:

(1) Step Test - Number of times you are able to step one foot fully onto, then off a 7.5 cm block in 15 s. Repeated for each leg.

(2) Timed up and go test – you will be required to stand from a chair, walk 3 meter as quickly and safely as possible, cross a line marked on the floor, turn around, walk back and sit down. You will be asked to do it for three times

(3) Functional Reach Test – You will be asked to extend your arm horizontally (approximately 90°) and then reach as far forward as you can without losing your balance or taking a step.

(4) Static Standing Balance – You will be asked to stand with feet together and eyes closed and on one leg for as long as you can, or until I say stop (up to 30 sec maximum).

(5) Hand Grip strength – You will be asked to apply as much grip pressure as possible on a force devise (hand dynamometer). You will perform this 2 times for each hand.

(6) Two-minute walk test – this test will be used to assess exercise tolerance. You will be asked to walk for 2 minutes and cover as much distance as possible.

(7) Lower limb muscle strength - The strength of your knee muscle in both legs will be measured by pulling against padded straps attached to strain gauges. While sitting, you will be asked to pull against the strap assembly with maximal force for 2 to 3 seconds, for 3 times.

(8) Measures of your walking: You will be asked to walk on a mat with your walking shoes at your self-selected comfortable speed several times.

Questionnaires:

You will also be asked to complete some short questionnaires to evaluate your health status, fear of falling, your actual level of physical activity and your social participation. These questionnaires are:

(1) The Short Form (12) Health Survey (SF-12) – This questionnaire evaluates the individual health status such as your physical functioning, bodily pain, general health perceptions, emotional status and mental health.

(2) The Incidental And Planned Exercise Questionnaire (IPEQ) will assess your physical activity level.

(3) The falls efficacy scale (Short FES-I) questionnaire will be also used to record your fear of falling during daily activities (such as when going up or down stairs).

(4) Social activity participation – you will be asked to record the number of times in the previous 2 weeks that you have participated in 10 categories of social activities, for example, gone to church, visiting friends and family or gone to concerts and plays.

(5) Physical self-perception will be measured using the Physical Self-Description Questionnaire (PSDQ). The PSDQ will ask you to think about yourself physically. For example, how good looking you are, how strong you are, how good you are at sports, whether you are physically coordinated, whether you get sick very often and so forth.

Short Exit Interview – If you are allocated to the exercise intervention group, you may be asked to participate in a short exit interview which will be carried out after you have concluded the exercise intervention period (18 weeks). This interview will be carried out just prior your first follow-up assessment (on the same day). You will be asked questions about your experience with the project. This interview will take around 15-20 minutes and all information you provide will be recorded using a digital voice recorder.

Monthly Falls and Physical Activity Calendar:

Additionally, you will be requested to record any falls experienced for the duration of the study using a monthly calendar. Physical activity or exercise you have performed during that month will also be recorded on the same calendar sheet and, at the end of each month, you will be required to return the diary to the researchers in a reply paid envelopes (which will be provided to you).

Who is conducting the study?

Mrs. Myrla Sales is conducting this study as part of her PhD research under the supervision of Professor Remco Polman and Dr. Pazit Levinger from Victoria University.

For more information or to organise a meeting, please call or send an email to Mrs. Myrla Sales, 0447 017 820 or myrla.reissales@live.vu.edu.au

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 3 - Semi-Structured Exit Interview Guide

INTERVIEW GUIDE

Introduction

1. Welcome
2. Consent interview and audiotaping the interview.
3. Confirmation of confidentially of information provided.
4. Inform participants that they can withdraw at any time during the interview.
5. Thanking participant for attending the interview and tell them what the interview is about (learning more about their experiences within the program and improve current practice).

Questions

1. Why did you volunteer to be part of the research project?

2. Could you tell me about your experiences from engaging in the training program, good or bad? (the abcd questions you only ask if they haven't spoken about it)
    a. What aspect of the project captured your imagination most?
    b. What was it about the training program that you really enjoyed?
    c. Are there aspects of the training program which you think could be done better?
    d. If any what difficulties did you experience from engaging in the training program (e.g., were there any barriers to participation?, if you skipped sessions, what were the main reasons for this?)?

3. What did you think about the frequency of the program (too frequent, just right, not enough and reasons)?

4. Was the length of the sessions of exercise adequate for you (too long, too short, and reasons)?

5. Was the progression in the program suited to your needs?

6. Could you say anything on the role of the exercise leader and the supervision you received during participation in the program?

7. As a result of you participating in the program, have you noticed any changes to your daily life? If yes, could you please describe them to me?

8. What do you think it may have caused this change to your daily life?

9. Is the training program something you would like to continue to participate in the future? If yes/no please explain.

10. Would you suggest this program to others?

11. If you would describe the program to this person in a few sentences what would you say?

12. On a scale from one to ten with one not useful and 10 extremely useful how would you rate the training program?

13. Is there anything else that you would like to mention about the project that wasn't asked here?

Appendix 4 – Medical History and Risk Assessment Questionnaire

Medical History and Risk Assessment

Participant ID: _______

Personal Details:

Name: ____ DOB: ___ / ___ / ______

Address: ____ Sex: ❑ M ❑ F

____

____ Age: _________ yrs

Telephone: Weight: _________ Kg

Mobile: _____________________ Height: _________ cm

Home: ______________________

Actual or Previous Occupation:

____

Highest Education Level:

❑ Postgraduate Degree
❑ Graduate Diploma or Graduate Certificate
❑ Bachelor Degree
❑ Advanced Diploma or Certificate
❑ Secondary Education (e.g. Year 12)
❑ Primary Education

Did you have or actually have any of the following conditions?

Medical Condition	No	Yes	Don't know	Medical Condition	No	Yes	Don't know
Heart Attack	❑	❑	n/a	Congenital Heart Disease	❑	❑	n/a
Chest Pain (angina)	❑	❑	❑	Disease of Arteries/Veins	❑	❑	❑
Heart Murmur	❑	❑	❑	Lung Disease (e.g., Emphysema, Asthma)	❑	❑	❑
Heart Rhythm Disturbance	❑	❑	❑	Stroke	❑	❑	❑
Heart Valve Disease	❑	❑	❑	Heart Failure	❑	❑	❑

Any life-threatening conditions	❑	❑	❑	Any contagious disorders	❑	❑	❑
Epilepsy	❑	❑	❑	High Blood Pressure	❑	❑	❑
Nerve Disorder	❑	❑	❑	Any form of cancer	❑	❑	❑
Disease or disorder of the digestive tract	❑	❑	❑	Arthritis	❑	❑	❑
Medical Condition	No	Yes	Don't know	Medical Condition	No	Yes	Don't know
Diabetes	❑	❑	❑	Hepatitis	❑	❑	❑
Kidney Disease	❑	❑	❑	Any Physical defect or deformity	❑	❑	❑
Disease or disorder of the blood	❑	❑	❑	Any vision or hearing disorders	❑	❑	❑
*Back or neck injury	❑	❑	❑	*Shoulder, elbow or wrist injury	❑	❑	❑
* Bleeding disorder	❑	❑	❑	*Hip, knee or ankle injury	❑	❑	❑

Please give more details to each option you have answered “Yes”:

____

____

____

____

____

____

List prescription and non-prescription medications you are taking:

__________________________ __________________________

__________________________ __________________________

__________________________ __________________________

__________________________ __________________________

__________________________ __________________________

Please inform if you have any drug sensitivity and allergies.

____
____
____

Have you had or been advised to have any surgical operation or medical procedure? Please inform each of them and the approximate year that they happened (e.g. Appendix (1979)).

__________________________ __________________________

__________________________ __________________________

__________________________ __________________________

As a result of exercise, have you ever experienced any of the following?

Symptom during exercise	No	Yes	Symptom during exercise	No	Yes
Pain or discomfort in the chest, back, arm, or jaw	❑	❑	Palpitations (heart rhythm disturbance)	❑	❑
Severe shortness of breath or problems with breathing during mild exertion	❑	❑	Pain in the legs during mild exertion	❑	❑
Dizziness, nausea or fainting	❑	❑	Severe heat exhaustion	❑	❑

Are you a current smoker?

❑ No ❑Yes If Yes, Average/day = ____

Are you an ex-smoker?

❑ No ❑Yes If Yes, Average/day = ____

Do you drink alcohol regularly?

❑ No ❑Yes If Yes, Average drinks/day = ____

Any other special medical information you would like to report:

____
____
____

Participant Declaration

I declare that the above information is to my knowledge true and correct, and that I have not omitted any information that is requested on this form.

Signed: ___________________________________ Date: ____ / ____ / ______

Appendix 5 – Participants' Education Level and Occupation

Table A.1: Participants' Education Level per Group

Education Level	**Total**	**%**
Control	*21*	
More than High School	12	57
Advanced Diploma or Certificate	4	19
Bachelor Degree	3	14
Graduate Diploma or Graduate Certificate	4	19
Postgraduate Degree	1	5
Less than High School	2	10
Primary Education	2	10
Completed Up to High School	7	33
Secondary Education	7	33
Intervention	*27*	
More than High School	11	41
Advanced Diploma or Certificate	4	15
Bachelor Degree	2	7
Graduate Diploma or Graduate Certificate	3	11
Postgraduate Degree	2	7
Less than High School	2	7
Primary Education	2	7
Completed Up to High School	14	52
Secondary Education	14	52
Grand Total	**48**	**-**

Table A.2: Participants' Occupation List Classified by Worker Collar-Colour - Control Group

Occupation	Total (%)
Blue-collar	**4 (19)**
Dressmaker	1
Electronic technician	1
Metal tradesman	1
Pensioner	1
Pink-collar	**13 (62)**
Admin/Hospitality	1
Community health	1
Kindergarten teacher	1
Midwife	1
Nurse	1
Occ. Health Nurse	1
Personal Assistant	1
Podiatrist	1
Secretarial	1
Teacher	1
Primary Teacher	2
Welfare Officer	1
White-collar	**4 (19)**
Hospitality manager/Aged care	1
Metallurgy engineer	1
Real Estate Agent	1
Sales director	1
Grand Total	**21**

Table A.3: Participants' Occupation List Classified by Worker Collar-Colour - Intervention Group

Occupation	**Total (%)**
Blue-collar	**6 (22.2)**
Bookbinder	1
Housewife	1
Plumber	1
Production management	1
Sheet Metal Worker	1
Tram driver	1
Pink-collar	**12 (44.4)**
Carer	1
Chemist	1
Civil marriage celebrant	1
Health Visitor	1
Insurance agent	1
Nurse	1
Nursing sister	1
Receptionist	2
Social Worker	1
Tailoring	1
Typist	1
White-collar	**9 (33.4)**
Accounting	2
Aircraft Engineer	1
Architect	1
Electronic Engineer	1
Fashion designer/Business director	1
General Manager	1
Mechanical Engineer	1
Office Manager	1
Grand Total	**27**

Appendix 6 – Relationships between Self Perceptions and Physical Activity Behaviour, Fear of Falling, and Physical Function among Older Adults

<u>Statement of contribution to co-authored published paper:</u>

This appendix includes a co-authored paper which was published in the European Review of Aging and Physical Activity Journal. The bibliographic details of this co-authored paper including all authors involved are:

Sales, M, Polman, R & Levinger, P, *Relationships between Self Perceptions and Physical Activity Behaviour, Fear of Falling, and Physical Function among Older Adults*. European Review of Aging and Physical Activity. 2017. 14(1). DOI: 10.1186/s11556-017-0185-3

My contributions to this paper involved the data analysis, designing, writing and preparation of the draft as well as the final version of this document. I responded to the comments raised during peer review process and made final amendments prior to publication.

21 Apr 2017

Myrla Sales

21 Apr 2017

Principal Supervisor: Associate Professor Pazit Levinger

Background

Perception of the physical self which includes appearance, function and ability to perform physical activities, may influence physical activity (PA) behaviour (i.e., engagement of planned and unplanned physical activities) among older adults. This is an important issue, because PA behaviour in the elderly is relatively low [1] when compared to what the guidelines for older adults' PA levels proposed by the American College of Sports Medicine (ACSM) recommends [2]. Lack of motivation, illness/disability, lack of leisure time or lack of financial resources have been mentioned as some of reasons for low levels of PA participation among older adults [3]. Furthermore, factors like fear of falling and physical functioning have been shown to influence PA behaviour as well as the quality of life in elderly populations [4-7]. Perceptions of the (physical) self are modifiable and as such could be targeted in interventions to increase PA behaviour and decrease fear of falling. This is also relevant to be addressed because low PA behaviour among older adults results in functional decline, restriction of social participation, gait and balance abnormalities, reduced cognitive functioning [8], and lower vitality in old age [9, 10].

The self is multidimensional and hierarchical in nature [11]. The hierarchical nature suggests that self-esteem is at the apex. At the middle of the hierarchy are perceptions about the self in more general domains (e.g., physical, social, academic) and at the base of the hierarchy are the perceptions of behaviour and functioning in specific situations (e.g., health, strength). Figure 1 represents this hierarchy taking into consideration the physical self-perceptions only. Physical self-worth has been shown to be correlated with global self-esteem through several studies [12, 13]. Global self-esteem, on its turn, is frequently taken as a powerful indicator of mental well-being. Furthermore, physical self-perceptions and the perceived importance of aspects of the physical self have consistently been related to exercise motivation [14, 15]. Moreover, evidence has shown that people, especially youth, who report high physical competencies (i.e., high physical self-perceptions) are more likely to enjoy PA and sustain interest in continuing involvement, which, in turn, enhances motivation to be physically active [16]. However, to date relatively little is known about the association between (physical) self-perceptions and PA behaviour in older adults.

As indicated, physical and global self-perceptions have been shown to be important correlates of levels of PA behaviour in children and adolescents [17]. In older adults, perceptions of aging have been shown to be associated with preventative health behaviours (including PA uptake) [18]. In addition, in a life style physical activity intervention immediate and long-term effects were found on increased self-esteem and a number of physical self-perception domains [19]. To date, however, it is equivocal whether there is an association between global and domain specific physical self-perceptions and self-reported PA behaviour in older adults. Because interventions to enhance PA behaviour in older adults have limited effects beyond the duration of the intervention [20] it would be important to explore correlates which could assist with long-term health behaviour change [19]. Therefore, this study examined the association between the 3 levels of the model for the self (global self-esteem, physical self-esteem and factors associated with the latter (e.g., strength, endurance, flexibility and body fat)) and self-reported planned and incidental PA behaviour (i.e., PA behaviour collected via questionnaires).

Similarly, the association between global and physical self-perceptions and fear of falling has not been explored to date. Whereas higher physical self-perceptions are associated with increased PA, higher levels of fear of falling have been shown to be a predictor of activity restriction and avoidance [21]. In addition, self-perceived ratings of health, a factor determining perceptions of the physical self, has been shown in two studies in older community dwelling participants in Brazil [22] and Taiwan [23] to be associated with increased levels of fear of falling. It would also be relevant to further investigate how fear of falling is related to PA behaviour because older adults might be hesitant to try new behaviours because of fear of injury [24]. More importantly, there is a need to establish the relationship between global and physical self-perceptions and fear of falling among older adults. Hence, both concepts are based on beliefs of the ability to execute competently and safely PA behaviours. By enhancing perceptions of the (physical) self it would be expected that this results in lower levels of fear of falling. As indicated, this might provide a new portal for intervention to enhance PA behaviour in older populations.

Physical functioning including objectively measured muscle strength and gait speed have been found to be correlates of PA behaviour and fear of falling in older adults [25-28]. Reduced physical functioning is also associated with reduced quality of life [25]. For example, reduced gait speed is an independent factors for falls [29] and is associated with disability, cognitive impairment, institutionalisation, and mortality among older adults [30]. The factors associated with physical self-perceptions (e.g., fitness, coordination, strength) are also assumed to be related to objectively measured physical functioning variables. Hence, studies examining the predictive validity of physical self-perceptions questionnaires have shown correlations between actual strength and self-perceived rating of strength [31]. As such it is important to examine the association between perceptions of the physical self and actual physical functioning. In addition, previous studies have failed to include objectively measured physical functioning factors in statistical models to examine how self-perceptions can predict PA behaviour and fear of falling above and beyond these factors.

An important issue is the selection of the appropriate questionnaire to assess (physical) self-perceptions in an elderly population. The literature shows a variety of instruments used to evaluate one's global and physical self-concept and self-perceptions [31]. Acknowledged as a leading multidimensional physical self-concept instrument [32], the Physical-Self Description Questionnaire (PSDQ) was designed to measure 11 aspects of physical self-concept [31]. The

PSDQ has been modified and translated to different languages and has consistently shown sound psychometrics across cultures, including Australian, Spanish and Turkish [33]. This questionnaire has demonstrated excellent psychometric properties, including internal consistency, internal validity, and predictive validity, comparable to other self-concept instruments [34]. However, this questionnaire has not been widely used among older adults and there is not much evidence of the relationships between the physical and global self-perceptions, fear of falling and objective measures of physical function.

Therefore, the aim of this study was to examine the relationships between global and physical self-perceptions and PA behaviour, fear of falling, and objective measures of physical function among community dwelling older adults. Based on the empirical literature we expected that more positive domain specific physical self-perceptions will be associated with increased self-reported PA behaviour (H1), and lower levels of fear of falling (H2) taking into consideration the functional status of individuals. We also expect that selected subdomains of the PSDQ will be associated to self-reported PA behaviour and objectively measured physical functioning supporting its predictive validity (H3).

Methods and Design

Participants

Sixty-six older people living in the community aged between 60 and 90 years old volunteered to be part of this cross-sectional study. We sought community-dwelling participants from diverse settings such as local senior organizations, retirement villages, community centres, senior clubs and associations in Melbourne. Participants were also recruited via community health promotion events and advertisement in local newspapers, magazines and online social networking media. Additionally, posters about the project were placed in healthcare facilities and places with high circulation of senior citizens and mail-out advertisements to health care practitioners in Melbourne.

The data used in this study was part of a randomized controlled trial which investigated the effectiveness of an exercise intervention in reducing older adults' falls risk. Older adults were selected to participate if they have had one or more falls in the previous 12 months or if they were concerned about having a fall.

A fall is defined as the act of inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or any other objects [28]. Volunteers were included if they were generally active and independent in the community (i.e., older adults able to engage in daily physical activity such as stair-climbing, do their own shopping or gardening, and able to participate at least three times weekly in moderate exercise such as swimming or walking) with no more than a single point stick (i.e., use of a cane but not a walker). Participants were excluded from this study if they had: 1) any uncontrolled non-musculoskeletal conditions that would make testing difficult and uncomfortable, such as chronic obstructive airways disease and congestive heart failure; 2) a pre-existing neurological or orthopaedic condition that affects lower limb strength (e.g. polio, stroke); 3) any of the following foot conditions: partial foot amputation or ulceration or foot fractures; 4) any uncontrolled musculoskeletal conditions that may affect ambulation (rheumatoid arthritis, gout, etc.). Participants with heart problems (e.g. chest pain (angina), heart murmur, heart rhythm disturbance, heart valve disease or heart failure) were required to obtain a medical clearance from their general practitioner in order to participate in this study. Participants with any documented medical condition or physical impairment that was judged by the medical practitioner to contraindicate their inclusion were excluded.

Protocol

All participants were fully informed about the nature of the study and signed a consent form. All testings, including assessment of strength and physical function and completion of set of questionnaires (fear of falling, physical self-perceptions and PA levels), were performed on the same day and took approximately 2h to be completed. This study was approved by the Human Research Ethics Committee of Victoria University, Melbourne (Application ID. HRE13-215).

Analysed Measures

Questionnaires

Physical self-perceptions were measured using the Physical Self-Description Questionnaire (PSDQ) – Short Form [34]. The PDSQ is a 40-item questionnaire scored from 1 (false) to 6 (true) and consists of 11 subdomains: Global self-esteem, Physical self-esteem, Health, Coordination, Activity, Body fat, Sport, Appearance, Strength, Flexibility, and Endurance. Each of these subdomains can reach a maximum value of 6. The PDSQ has been shown to have good test-retest stability over a 3-month period (r = .81 to .94) strong factorial structure and discriminant and convergent validity [34].

The Incidental and Planned Exercise Questionnaire *(IPEQ)* for older people was used to assess PA behaviour of the participants [35]. The IPEQ is a self-report questionnaire that covers the frequency and duration of several levels of planned and incidental PA in older people. Planned activities (6-items) include planned exercise or walks whereas incidental physical activities (6-items) include day-to-day activities like housework or gardening. Total hours per week spent in both incidental and planned PA are obtained by multiplying frequency scores and duration scores. Summation of the incidental and planned PA hours per week also provided a total activity score. The IPEQ has been shown to have good test-retest reliability and concurrent and face validity [35].

The falls efficacy scale (Short FES-I) questionnaire was used to record fear of falling [36]. The FES-I consists of 7 items using a Likert scale that assesses the participant's level of concern regarding the possibility of falling when performing certain daily activities. Items are scored from 1 = *'not concerned at all'* to 4 = *'very concerned'*. The total score ranges from 7 (not concerned) to 28 (severe concern) where higher scores being associated with a greater fear of falling [36]. The test–retest reliability of the Short FES-I is good (r = .92) [36].

Objective Measures of Strength and Physical Function

Hand grip strength test [37] was used to measure physical strength. Hand-grip strength is a simple, reliable, inexpensive surrogate of overall muscle strength and a valid predictor of physical disability and mobility limitation [38]. Using a TTM® digital hand dynamometer (Mentone Educational Centre, Melbourne, VIC), participants were asked to perform two maximum force trials with each hand and the best score of two attempts was recorded. Participant performed the test seated on a 43cm high chair, feet flat on the floor, with shoulder adducted and neutrally rotated, elbow flexed at 90° and forearm in neutral and the wrist between 0 and 30 degrees extension and between 0 degrees and 15 degrees ulnar deviation [39]. The maximum values of the left- and right-hand grip measurements were summed and be used for the analysis to remove consideration of hand dominance [37].

Lower limb strength was assessed via the sit-to-stand test [40] and measurement of the strength of the knee extensor muscles using a purposely built force transducer [41]. The sit to stand test is a simple test used to measure mobility and lower limb strength [40] and is also included in fall risk assessments [42, 43]. Participants were asked to sit and stand from a 43cm high chair as many times as possible for a period of 30 seconds without any assistance of the assessor. Participants were asked not to use their arms to help them rising from the chair or sitting. Thus, during the test, arms were kept crossed at the wrists and held against the chest or to the side of their body. At the signal "ready and go," participants rose to a full stand (body straight) and then returned back to the initial seated position (fully seated with back against the chair). The score was the total number of stands executed correctly within 30 seconds and a full stand was counted when the participants was more than halfway up at the end of the time. Incorrectly executed stands were not counted.

The strength of the knee extensor muscles of both limbs was measured with a purposely built force transducer which was attached to the participant's leg using a webbing strap with a Velcro fastener. The participant sat on a tall chair with a strap around the lower leg 10 cm above the ankle joint, and the hip and knee joint angles were positioned at 90 degrees. The distance from the knee joint to the strap around the ankle was measured with a tape measure. This measure was used for the calculation of torque (i.e. force [N] distance [m]). The maximum voluntary contraction was assessed during an isometric knee extension. Participants were asked to perform three maximum voluntary contractions trials on their dominant leg. The contractions last up to five seconds each, with a rest period of one minute between each trial. The force data were stored on a portable computer. The best performance of the three trials was considered as the maximum torque and used for analysis.

Assessment of gait speed was performed with the use of the GaitRite® system (CIR System, Inc, Harverton PA) instrumented walkway system (active length of the mat: 8.75m). Participants were asked to start from a point 3m in front of the mat and stopped on a point 3m behind the mat. Approximately 10 strides per participant were required to achieve reliable mean estimates of spatio-temporal gait parameters including velocity, stride and step length, and step and single support time [44]. Therefore, seven walks were recorded to allow sufficient data to be collected. Multiple practice trials were given until participants felt comfortable and could walk with consistent velocity. This was followed by seven testing trials which allowed sufficient number of strides to be recorded. Participants who used a gait aid for indoors walking were allowed to use it during the tests. Participants were wearing flat shoes during the test.

Data Management and Statistical Analysis

All analyses were completed using SPSS version 22.0 and a p value equal or less than 0.05 was considered statistically significant. Backwards multiple regression analyses using the entry method were performed to evaluate the relationship between (1) physical self-perceptions and objectively measured physical functioning (independent variables) and self-reported PA behaviour (dependent variable); (2) physical self-perceptions and objectively measured physical functioning (independent variables) and fear of falling (dependent variable). Variables were excluded if the change in explained variance was non-significant ($p > .05$). This method would allow for the most parsimonious relationship between the independent variables and dependent variables (PA behaviour and Fear of Falling).

Age, gender and history of falls have been shown to influence physiological functioning. In particular, physiological functioning declines with increasing age [45] and is moderated by gender with men declining twice as fast compared to women [27]. These changes are also accelerated if there is a history of falls [46]. As such we first explored, using regression analysis, whether the dependent variables (PA behaviour and Fear of Falling) were influenced by these demographic data. If this was the case, they would be incorporated as covariates.

Finally, we calculated Pearson product moment correlations between factors of the PSDQ and objective measures of physical functioning and fear of falling (H3) to examine its predictive validity.

Results

Participants' Characteristics

Participants' characteristics including medications, history of previous falls, levels of PA, fear of falling and physical performance characteristics are shown on Table 1. Table 2 provides an overview of the Pearson product moment correlations between the study variables.

Preliminary analysis

For all analyses the histograms and P-P plots indicated that the data and residuals were normally distributed. In addition, there were no outliers or collinearity (all Tolerance > .01 and VIF < 10) and the scatterplots indicated homoscedasticity. Regression analysis for Planned ($p = .94$), Incidental ($p = .87$), and Total ($p = .86$) PA did not show an association with age, gender or history of falls. However, for Fear of Falling ($p = .02$; $R^2 = .15$) history of falls was found to be a significant associated (Beta = .254; $p = .04$).

H1: Predictors of PA

The backwards multiple regression analysis for Planned PA showed that the best model explained 49.3% of the variance ($F(4,64) = 16.59$; $p < .001$). The PSDQ subdomains Activity (Beta = .581; $p < .001$) and Coordination (Beta = -.317; $p = .004$), and sit-to-stand (Beta = .176; $p = .05$) reached significance whereas the PSDQ subdomain General Physical approached significance (Beta = .240; $p = .06$).

The best model for Incidental PA explained 15% of the variance ($F(3,60) = 4.66$; $p = .005$). The PSDQ subdomains Coordination (Beta = -.491; $p = .002$) and Endurance (Beta = .399; p = 003) reached significance whereas Global Self-Esteem approached significance (Beta = .260; $p = .06$).

Finally, the best model for Total PA explained 42.6% of the variance ($F(5,59) = 8.75$; $p < .001$). The PSDQ subdomains Activity (Beta = .280; $p = .04$), Coordination (Beta = -.638; $p < .001$), Endurance (Beta = .334; $p = .01$) and Flexibility (Beta = .287; $p = .05$) reached significance whereas Global Self-Esteem approached significance (Beta = .225; $p = .06$).

H2: Predictors of fear of falling

The best backwards multiple regression model for fear of falling, controlling for falls history, was significant ($F(7,57) = 8.22$; $p < .001$) explaining 50.2% of the variance. The PSDQ subdomains Global Self-Esteem (Beta = -.409; $p < .001$), General Physical Self-Esteem (Beta = -.350; $p = .009$), Flexibility (Beta = -.560; $p < .001$) and Strength (Beta = .296; $p = .03$), and the objectively measured measure Knee Strength (Beta = -.356; $p = .001$) were significantly associated with fear of falling.

H3: Association PSDQ subdomains and objectively measured physical functioning.

Table 2 provides the Pearson product moment correlations between the subdomains of the PSDQ and the objectively measured physical functioning variables. There were no significant associations between the PSDQ subdomains and gait speed. Grip strength was associated with the strength factor, sit-to-stand with flexibility, sport competence and health whereas knee strength was associated with strength and health.

Discussion

This study examined the relationship between global and physical self-perceptions, self-reported PA and fear of falling taking into consideration objective measures of physical functioning, in a sample of community dwelling older adults. Findings showed that, higher physical self-perceptions of activity and better sit-to-stand performance but lower ratings of one's coordination was associated with higher self-reported planned PA behaviour whereas higher physical self-perceptions of endurance and global self-esteem and lower levels of coordination was associated with increased self-reported incidental PA behaviour. Similarly, increased total PA behaviour was associated with higher ratings of the physical self-perceptions of activity, endurance, flexibility and global self-esteem but lower levels of coordination (H1). More falls, lower levels of global self-esteem, domain specific physical self-esteem as well as flexibility and objectively measured knee strength was associated with increased fear of falling whereas strength had an inverse association (H2). There were also associations between some of the objectively measured physical functioning variables and the individual's self-perceptions of the physical self, providing some predictive validity for the PDSQ (H3).

Despite research trying to identify correlates of PA behaviour, few studies have examined the influence of global or domain specific physical self-perceptions. In addition, findings on the relationship between self-perceptions and PA behaviour have been equivocal. Moore and colleagues recently showed that higher perceptions of health was strongly associated with increased PA [47] whereas other authors showed significant direct effects between perceptions of strength-, condition- and body-esteem and self-reported PA [48]. However, the latter study only measured four domains of the physical self.

The PSDQ subdomain coordination was associated with planned, incidental and total PA behaviour. Surprisingly, lower levels of coordination were associated with higher levels of self-reported planned, incidental and total PA. It is unclear why this is the case. However, we would speculate that those who perceive their coordination to be lower engage in physical activities which are of lower complexity (e.g., walking). However, this would require further investigation. It is not surprising that perceptions of activity (i.e., being active) was associated with planned and total PA but not incidental PA given that older adults who perceive themselves as more active may feel themselves more competent to engage in more structured and planned forms of PA. A study showed that older adults who perceive themselves as such reported also greater physical self-worth and global self-esteem which are directly associated with physical activity behaviour [48]. Similarly, our study also indicated that physical self-esteem was associated with planned but not incidental PA behaviour.

Incidental and total PA, on the other hand, was associated with perceptions of one's endurance (i.e., not tiring when exercising hard) and global self-esteem. Higher levels of physical fitness and endurance have been shown to indirectly influence PA behaviour through increased exercise related self-efficacy [49]. Global self-esteem has been found to decline in older individuals [50]. In addition, self-esteem is associated with well-being, health, life-satisfaction and quality of adaptation [51]. Also, it is associated with social integration and ability to cope with physical and cognitive decline happening in older age [51]. Conversely, other studies have suggested that not all older adults are likely to be exposed to declines in their self-esteem with some maintaining it fairly stable or even increasing their levels throughout adulthood [52]. It is also believed that self-esteem could change for different older adults in different directions [53] and one way that it could be improved would be through interventions [19, 54]. Finally, increased levels of total PA behaviour were associated with higher perceptions of one's flexibility.

Overall, our study showed that global and specific physical self-perceptions had closer associations with self-reported planned and incidental PA than objective measures of physical functioning. Only the sit-to-stand physical functioning test was associated with planned PA. This is an important finding and provides support for the multidimensional and hierarchical Exercise and Self-Esteem Model [55] in explaining the relationship between self-perceptions and PA. It suggests that PA influences self-efficacy (i.e., the belief in your ability to complete a physical task) – not measured in the present study – which, in turn, impacts areas of physical competence (e.g., coordination, endurance/fitness and activity) which then, directly and indirectly (through physical self-worth), influences global self-esteem [47]. Research has previously also showed that the main barriers to engaging in PA among older people are attitudinal [56]. It is therefore relevant that the non-physical aspects of PA, such as (physical) self-perceptions are also taken into account when designing intervention programmes [56]. Hence, through enhancing individuals' global self-esteem and domain specific physical self-perceptions, PA levels might be increased either directly or indirectly [19].

Fear of falling tends to constrain and limit older people's activity and mobility which in turn can reduce physical conditioning and reducing muscular strength [46]. Decreased mobility and muscle atrophy lead to more accidental falls, which in some studies has been associated with increased fear of falling [57]. We found that increased number of falls resulted in increased fear of falling of falling and controlled for this in our analysis. All 3 levels of the model of the self (global self-esteem, physical self-esteem and its factors flexibility and strength) as well as actual knee strength was associated with 50.2% of variance in fear of falling. Like coordination and PA behaviour, perceptions of strength had an inverse association and it is unclear why this is the case.

Few studies have examined the role of global self-esteem or a broad spectrum of perceptions of the physical self in relation to fear of falling. There is some support for the influence of objectively measured factors on fear of falling. One previous study showed that reduced physical functioning and slower gait speed was associated with higher fear of falling [58]. In addition, elderly individuals who have irrational fears are more likely to interpret physical impairments negatively with the potential to influence physical functioning (e.g. fear induced co-contraction) [59]. However, this present study is the first one which has demonstrated that perceptions of global self-esteem, physical self-esteem, flexibility and strength are also important in levels of fear of falling. Surprisingly, the factors associated with fear of falling have been shown to be different from those related to actual falls [60]. Falls are related to age, gait speed and being depressed whereas fear of falling has been associated with age, cognitive impairment, lower social activity and being female [60]. Our findings also indicated that a history of more falls was associated with higher levels of fear of falling.

Few studies have examined the predictive validity of the PSDQ. Similar to Brewer and Olson [61], we found a moderate correlation between the strength factor of the PDSQ and grip and knee strength. The latter was also associated with rating of health. The sit-to-stand task is generally considered a measure of functional performance and has been shown to be influenced by a number of physiological and psychological factors [62]. The present study suggests that the sit-to-stand test is associated with the flexibility, sport competence and health subdomains of the PSDQ. Although gait speed has been shown to be associated with health related outcomes in normally functioning older individuals [63] we did not find an association between gait speed and any global and domain specific physical self-perceptions. This is a surprising finding and further research is required to examine this issue. Our findings provide some support for the predictive validity of the PSDQ in a sample of community dwelling older adults.

It has been unclear whether all domains assessed in the PSDQ are relevant to older individuals. Consistent with previous research, the present study showed that older individuals scored lower for the subdomains sport [19] and endurance [34] compared to young adults. However, these latter authors also showed lower scores for health and body fat whereas some other authors found lower scores for flexibility and coordination [64]. Ratings of the self are very much influenced by the frame of reference used by individuals as well as actual performance. Thus, lower average scores in a number of areas of physical self-worth can be due to declines with age and older adults' ratings of global self-esteem and physical self-worth are more likely to be related to social comparisons with individuals of similar age [34].

Practical implications

Overall, we found an association between global and domain specific physical self-perceptions. This finding might provide a pathway for developing strategies for the adoption and maintenance of PA behaviour in older individuals as previously suggested [63]. This could be accomplished by matching exercise interventions to the self-perceptions of individuals or by developing interventions which influence physical self-perceptions in order to individuals becoming more likely to take-up and maintain a PA routine. For example, practitioners could consider interventions which match low physical self-perceptions to coordination or endurance. The former might result in individuals being advised in engaging in Tai Chi type of activities whereas the latter might result in advice to engage in activities like walking or cycling.

Previous research has suggested that a person's attitudes, actions and behaviours are guided by their beliefs [65, 66]. Therefore, as also supported by our findings, interventions aimed at reducing falls or fear of falling among older adults should take into consideration global and domain specific physical self-perceptions. This could be accompanied by goal-setting [67], life coaching [68] and behaviour change strategies [69, 70] to address engagement and adherence to interventions aiming to reduce risk of falls and fear of falling [71]. For example, a recent study has demonstrated that an intervention that combines cognitive-behaviour strategies can help older adults to manage their fear of falling, falls, decrease their depressive inclination, and enhance their mobility and muscle strength [72].

Limitations

While this study provides useful information about the relationships between perceptions global and physical self-perceptions, self-reported PA, fear of falling and objective measures of physical function among older adults several limitations are acknowledged. Firstly, we used a relatively small convenient sample. Although this makes generalisation of findings problematic, the participants included in the study were recruited from an area of Melbourne which is likely to resemble healthy older adults in Australia in general. Secondly, a disparity in gender was present where more females volunteered to be part of this study. Similarly, we had an unequal number of fallers/non-fallers recruited. Therefore, further research is needed with a more homogeneous sample of older adults. Also, there is still some unexplained variance in the evaluated measures and questionnaires which indicates that other subdomains may play a role in the investigated relationships. We would like to acknowledge that in our cross-sectional study we assumed that self-perceptions predicted PA behaviour. However, we cannot establish cause and effect and it is likely that there is a reciprocal relationship between self-perceptions and PA behaviour. Finally, the information regarding the levels of physical activity of participants was evaluated and accounted for via the Incidental and Planned Exercise Questionnaire. An alternative to minimize errors due to inaccurately reported PA behaviour would be to measure physical activity behaviour objectively. Therefore, for future studies, an objective method for assessing PA behaviour such as accelerometers or pedometers would be recommended to be included.

Conclusion

Findings showed that global and physical self-perceptions are associated with planned (49.3%) and incidental (15%) PA behaviour and fear of falling (50.2%). Some of the objectively measured physical functioning variables were associated to the individual's self-perceptions of the physical self, providing some predictive validity for the PDSQ. The findings of this study come to corroborate that the belief system of older adults ideally need to be taken into consideration when designing interventions that aim to increase PA behaviour, reduce fear of falling or actual fall. Coupling that with goal-setting, life coaching and behaviour change strategies would also be beneficial to address engagement and adherence to such interventions.

Abbreviations

Short-FES-I: The Falls Efficacy Scale; PSDQ: Physical Self-Description Questionnaire; IPEQ: Incidental and Planned Exercise Questionnaire; RCT: randomised controlled trial.

PA: Physical activity.

References

1. Smith L, et al., *Patterns and correlates of physical activity behaviour over 10 years in older adults: prospective analyses from the English Longitudinal Study of Ageing.* BMJ open. 2015. 5(4):e007423.
2. Nelson ME, et al., *Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association.* Circulation. 2007. 116(9):1094.
3. Chinn DJ, et al., *Barriers to physical activity and socioeconomic position: implications for health promotion.* J. Epidemiol. Community Health. 1999. 53(3):191.
4. Jefferis BJ, et al., *How are falls and fear of falling associated with objectively measured physical activity in a cohort of community-dwelling older men?* BMC Geriatr. 2014. 14(1):1.
5. Scheffer AC, et al., *Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons.* Age Ageing. 2008. 37(1):19-24. DOI: 10.1093/ageing/afm169.
6. Schepens S, et al., *Relationship between fall-related efficacy and activity engagement in community-dwelling older adults: a meta-analytic review.* Am. J. Occup. Ther. 2012. 66(2):137-148.
7. Zijlstra GA, et al., *Interventions to reduce fear of falling in community-living older people: a systematic review.* J. Am. Geriatr. Soc. 2007. 55(4):603-15. DOI: 10.1111/j.1532-5415.2007.01148.x.
8. Johnson LG, et al., *Light physical activity is positively associated with cognitive performance in older community dwelling adults.* J. Sci. Med. Sport. 2016. 19(11):877-882.

9. Landers MR, et al., *Balance confidence and fear of falling avoidance behavior are most predictive of falling in older adults: prospective analysis.* Phys. Ther. 2015.

10. Rochat S, et al., *What is the Relationship Between Fear of Falling and Gait in Well-Functioning Older Persons Aged 65 to 70 Years?* Arch. Phys. Med. Rehabil. 2010. 91(6):879-884. DOI: http://dx.doi.org/10.1016/j.apmr.2010.03.005.

11. Shavelson RJ, Hubner JJ, and Stanton GC, *Self-concept: Validation of construct interpretations.* Review of educational research. 1976. 46(3):407-441.

12. Fox KR, *The physical self: From motivation to well-being*. 1997: Human Kinetics.

13. Harter S, *Historical roots of contemporary issues involving self-concept*, in *Handbook of self-concept: Developmental, social, and clinical considerations*, B.A. Bracken, Editor. Wiley: New York. 1996. p. 1-37.

14. Marsh HW and Sonstroem RJ, *Importance ratings and specific components of physical self-concept: Relevance to predicting global components of self-concept and exercise.* Journal of Sport and Exercise Psychology. 1995. 17(1):84-104.

15. Sonstroem RJ, *Physical self-concept: assessment and external validity.* Exerc. Sport Sci. Rev. 1997. 26:133-164.

16. Biddle SJ, et al., *Motivation for physical activity in young people: Entity and incremental beliefs about athletic ability.* Journal of Sports Science. 2003. 21(12):973-989.

17. Crocker P, et al., *Predicting change in physical activity, dietary restraint, and physique anxiety in adolescent girls: Examining covariance in physical self-perceptions.* Can J Public Health. 2003. 94(5):332-337.

18. Levy BR and Myers LM, *Preventive health behaviors influenced by self-perceptions of aging.* Prev. Med. 2004. 39(3):625-629.

19. Opdenacker J, Delecluse C, and Boen F, *The longitudinal effects of a lifestyle physical activity intervention and a structured exercise intervention on physical self-perceptions and self-esteem in older adults.* J. Sport Exerc. Psychol. 2009. 31(6):743-760.

20. Müller-Riemenschneider F, et al., *Long-term effectiveness of interventions promoting physical activity: a systematic review.* Prev. Med. 2008. 47(4):354-368.

21. Hadjistavropoulos T, Delbaere K, and Fitzgerald TD, *Reconceptualizing the role of fear of falling and balance confidence in fall risk.* J. Aging Health. 2011. 23(1):3-23.

22. Malini FM, Lourenço RA, and Lopes CS, *Prevalence of fear of falling in older adults, and its associations with clinical, functional and psychosocial factors: The Frailty in Brazilian Older People‐ Rio de Janeiro Study.* Geriatrics & gerontology international. 2015.

23. Chang H-T, Chen H-C, and Chou P, *Factors associated with fear of falling among community-dwelling older adults in the Shih-Pai Study in Taiwan.* PLoS One. 2016. 11(3):e0150612.

24. Australian Institute of Health and Welfare. *Falls in Older People*. 2013. http://www.aihw.gov.au/injury/falls/. Accessed 01/03/2017.

25. Akosile CO, et al., *Fear of falling and quality of life of apparently-healthy elderly individuals from a Nigerian population.* J. Cross. Cult. Gerontol. 2014. 29(2):201-209.

26. Dishman RK and Sallis JF, *Determinants and interventions for physical activity and exercise*, in *Physical activity, fitness, and health: International proceedings and consensus statement* C. Bouchard, R.J. Shephard, and T. Stephens, Editors. Human Kinetics: Champaign, IL. 1994. p. 214-238.

27. Goodpaster BH, et al., *The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging and body composition study.* J Gerontol A Biol Sci Med Sci. 2006. 61(10):1059-1064.

28. World Health Organization and Ageing Life Course Unit. *WHO global report on falls prevention in older age*. 2008. Geneva. Accessed 01/03/2017.

29. Verghese J, et al., *Quantitative gait markers and incident fall risk in older adults.* J Gerontol A Biol Sci Med Sci. 2009. 64(8):896-901.

30. Van Kan GA, et al., *Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force.* J. Nutr. Health Aging. 2009. 13(10):881-889.

31. Marsh HW, et al., *Physical Self Description Questionnaire: psychometric properties and multitrait-multimethod analysis of relations to existing instruments.* J. Sport Exerc. Psychol. 1994. 16:270-305.

32. Byrne B, *Measuring self-concept across the lifespan: Methodology and instrumentation for research and practice.* Washington, DC: American Psychological Association. 1996.

33. Marsh HW, Marco IT, and Apçý FH, *Cross-cultural validity of the Physical Self-Description Questionnaire: Comparison of factor structures in Australia, Spain, and Turkey.* Res. Q. Exerc. Sport. 2002. 73(3):257-270.

34. Marsh HW, Martin AJ, and Jackson S, *Introducing a short version of the Physical Self Description Questionnaire: New strategies, short-form evaluative criteria, and applications of factor analyses.* J. Sport Exerc. Psychol. 2010. 32(4):438-482.

35. Delbaere K, Hauer K, and Lord SR, *Evaluation of the incidental and planned activity questionnaire (IPEQ) for older people.* Br. J. Sports Med. 2010. 44(14):1029-34. DOI: 10.1136/bjsm.2009.060350.

36. Kempen GI, et al., *The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling.* Age Ageing. 2008. 37(1):45-50.

37. Tromp A, et al., *Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly.* J. Clin. Epidemiol. 2001. 54(8):837-844.

38. Sallinen J, et al., *Hand‐ Grip Strength Cut Points to Screen Older Persons at Risk for Mobility Limitation.* J. Am. Geriatr. Soc. 2010. 58(9):1721-1726.

39. Richards L and Palmiter-Thomas P, *Grip strength measurement: a critical review of tools, methods, and clinical utility.* Crit Rev Phys Rehabil Med. 1996. 8(8):87-109.

40. Csuka M and McCarty DJ, *Simple method for measurement of lower extremity muscle strength.* Am J Med. 1985. 78(1):77-81.

41. Lord SR, Menz HB, and Tiedemann A, *A physiological profile approach to falls risk assessment and prevention.* Phys. Ther. 2003. 83(3):237-52.

42. Tinetti ME, *Performance-oriented assessment of mobility problems in elderly patients.* J. Am. Geriatr. Soc. 1986. 34(2):119-126.

43. Berg KO, et al., *Measuring balance in the elderly: validation of an instrument.* Can J Public Health. 1992. 83(2):S7-11.

44. Hollman JH, et al., *Number of strides required for reliable measurements of pace, rhythm and variability parameters of gait during normal and dual task walking in older individuals.* Gait Posture. 2010. 32(1):23-28.

45. Whitbourne SK, *The aging body: Physiological changes and psychological consequences*. 2012: Springer Science & Business Media.

46. Delbaere K, et al., *Fear-related avoidance of activities, falls and physical frailty. A prospective community-based cohort study.* Age Ageing. 2004. 33(4):368-373.

47. Moore JB, et al., *Physical self-esteem in older adults: A test of the indirect effect of physical activity.* Sport Exerc Perform Psychol. 2012. 1(4):231-241.

48. McAuley E, et al., *Physical activity, self-efficacy, and self-esteem: Longitudinal relationships in older adults.* The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2005. 60(5):P268-P275.

49. McAuley E, Courneya KS, and Lettunich J, *Effects of acute and long-term exercise on self-efficacy responses in sedentary, middle-aged males and females.* The gerontologist. 1991. 31(4):534-542.

50. Orth U, Trzesniewski KH, and Robins RW, *Self-esteem development from young adulthood to old age: a cohort-sequential longitudinal study.* J. Pers. Soc. Psychol. 2010. 98(4):645.

51. Alaphilippe D, *Self-esteem in the elderly.* Psychol. Neuropsychiatr. Vieil. 2008. 6(3):167-176.

52. Wagner J, et al., *The nature and correlates of self-esteem trajectories in late life.* J. Pers. Soc. Psychol. 2013. 105(1):139.

53. Liu SY, et al., *Self-esteem change and diurnal cortisol secretion in older adulthood.* Psychoneuroendocrinology. 2014. 41:111-120.

54. Motl RW, et al., *Depressive Symptoms Among Older Adults: Long-Term Reduction After a Physical Activity Intervention.* J. Behav. Med. 2005. 28(4):385. DOI: 10.1007/s10865-005-9005-5.

55. Sonstroem RJ and Morgan WP, *Exercise and self-esteem: rationale and model.* Med. Sci. Sports Exerc. 1989. 21(3):329-337.

56. Lee L-L, Arthur A, and Avis M, *Using self-efficacy theory to develop interventions that help older people overcome psychological barriers to physical activity: a discussion paper.* Int. J. Nurs. Stud. 2008. 45(11):1690-1699.

57. Nantsupawat N, et al., *Gait Characteristics in Patients With Chronic Obstructive Pulmonary Disease.* J. Prim. Care Community Health. 2015. 6(4):222-226.

58. Reelick MF, et al., *The influence of fear of falling on gait and balance in older people.* Age Ageing. 2009. 38(4):435-440.

59. Delbaere K, et al., *Determinants of disparities between perceived and physiological risk of falling among elderly people: cohort study.* BMJ. 2010. 341:c4165.

60. Clemson L, et al., *Predictors of Injurious Falls and Fear of Falling Differ An 11-Year Longitudinal Study of Incident Events in Older People.* J. Aging Health. 2015. 27(2):239-256.

61. Brewer WA and Olson SL, *Are there relationships between perceived and actual measures of physical fitness and health for healthy young women?* Compr Psychol. 2015. 4(1). DOI: 10.2466/06.CP.4.2.

62. Lord SR, et al., *Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people.* J Gerontol A Biol Sci Med Sci. 2002. 57(8):M539-M543.

63. Cesari M, et al., *Prognostic Value of Usual Gait Speed in Well- Functioning Older People - Results from the Health, Aging and Body Composition Study.* J. Am. Geriatr. Soc. 2005. 53(10):1675-1680.

64. Paterson DH and Warburton DE, *Review Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines.* Int J Behav Nutr Phys Act. 2010. 7(38):1-22.

65. Ajzen I and Fishbein M, *Belief, attitude, intention and behavior: An introduction to theory and research*. 1975, Reading, MA: Addison-Wesley.

66. Jensen MP, et al., *Patient beliefs predict patient functioning: further support for a cognitive-behavioural model of chronic pain.* Pain. 1999. 81(1):95-104.

67. Oettingen G and Gollwitzer PM, *Goal setting and goal striving*, in *Blackwell handbook of social psychology: Intraindividual processes*, A. Tesser and N. Schwarz, Editors. Blackwell: Oxford, England. 2001. p. 329-348.

68. Green L, Oades L, and Grant A, *Cognitive-behavioral, solution-focused life coaching: Enhancing goal striving, well-being, and hope.* J Posit Psychol. 2006. 1(3):142-149.

69. Bandura A, *Social foundations of thought and action: A social cognitive theory*. 1986, Englewood Cliffs, NJ: Prentice-Hall, Inc.

70. McAuley E, et al., *Self-regulatory processes and exercise adherence in older adults: executive function and self-efficacy effects.* Am. J. Prev. Med. 2011. 41(3):284-290.

71. Yardley L, et al., *Recommendations for promoting the engagement of older people in activities to prevent falls.* Qual Saf Health Care. 2007. 16(3):230-234.

72. Huang T-T, et al., *Evaluation of a combined cognitive-behavioural and exercise intervention to manage fear of falling among elderly residents in nursing homes.* Aging & mental health. 2016. 20(1):2-12.

Table 1: Sample means and deviations for study variables

Characteristic	**Number, % or Mean ± SD**	**Range**
Participants (number)	66	-
Age (Years)	71.9 ±6.67	61-89
Number of Females in the sample	71.21	
BMI (kg/m^2)	28.82 ±5.19	21.4-43.6
Average Number of Medications	3.20 ±2.15	1-10
Falls History (%, ≥ 1 fall in the last 12 months)	68.2	
Questionnaires		
Fear of Falling	10.97 ±4.02	7-25
IPEQ		
Incidental Physical Activity	13.30 ±5.78	1.75-26.2
Planned Physical Activity	4.14 ±3.98	0-17.0
Total Physical Activity	17.35 ±8.04	1.75-35.7
PSDQ		
Physical Activity	2.71 ±1.56	1.0-6.0
Appearance	3.35 ±1.39	1.0-6.0
Body Fat	3.10 ±1.77	1.0-6.0
Coordination	4.05 ±1.17	1.0-6.0
Endurance	2.47 ±1.21	1.0-5.3
Global Self-Esteem	4.60 ±0.91	1.4-6.0
Flexibility	3.61 ±1.33	1.0-6.0
Physical Self-Esteem	3.96 ±1.31	1.0-6.0
Health	4.98 ±1.11	2.0-6.0
Sport	2.48 ±1.40	1.0-6.0
Strength	3.56 ±1.13	1.3-5.6
Strength Measures		
Hand Grip Strength (R+L hand, Kg)	23.79 ±9.86	0*-47
Knee Extensor Muscle Strength (Dominant Leg, N/m)	80.32 ±32.14	17-186
Physical Function		
Sit to Stand (repetitions)	10.67	0*-19
Gait Speed (cm/sec)	**133.19**	**89.5-184.9**

*: Participant could not do the test due to knee pain and arthritis on the hand, so the value of the test for this participant was excluded from the mean. SD = Standard deviation; BM = Body Mass Index; IPEQ = Incidental and Planned Exercise Questionnaire. PSDQ = Physical Self-Description Questionnaire.

Table 2: Prediction properties of the PSDQ subdomains with objectively measured variables of muscle strength and physical. Values are Pearson product moment correlations.

	Gait speed	Grip strength	Sit-to-stand	Knee strength
Physical activity	.14	-.13	.10	-.02
Appearance	.22	.15	-.07	.03
Body fat	.08	.11	.03	.02
Coordination	.09	.19	.05	.20
Endurance/fitness	.04	.11	.24*	.15
Flexibility	.18	.12	.25*	.22
Sport competence	-.03	.21	.12	.29*
Strength	.13	.35**	.22	.42**
Health	.04	.10	.25*	.06
Physical Self-Esteem	.02	.06	.06	.12
Global Self-Esteem	-.06	.09	-.01	-.03

*: $p < 0.05$. **: $p < 0.01$. PSDQ = Physical Self-Description Questionnaire.

Figure 1: Representation of the hierarchical nature of the self in relation to physical aspects. (Source: Fox KR and Corbin CB, The physical self-perception profile: Development and preliminary validation. Journal of sport and Exercise Psychology. 1989. 11(4):408-430).