Curtin School of Allied Health

Physical Activity Opportunities for Older People

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number HRE2019-0734 dated 28 October 2019, Approval Number HRE2019-0735 dated 28 October 2019 and Approval Number HRE2020-0271 dated 29 May 2020.

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Abstract

In general, older Australians have low levels of physical activity. In order to achieve maximum health effects, including a reduction in falls and improvements in function, physical activity programs should be multi-modal, and include balance and strength training. Novel approaches to increasing multi-modal physical activity are required, and outdoor exercise parks are one avenue with recent research interest. From a health promotion perspective, it is also important to target these types of interventions to people at the early stages of developing balance impairments (termed mild balance dysfunction) rather than delay interventions until moderate impairments or injurious falls occur.

This thesis consists of a series of five linked studies. A systematic review was initially conducted, showing that although some older adults used outdoor exercise parks, participation rates were low, and meta-analysis results evaluating changes in balance and lower body strength were not significant. One potential factor limiting the evaluation of balance in higher functioning older adults is the presence of ceiling effects in outcome measures. The Community Balance and Mobility Scale (CBMS) is a balance and mobility assessment that has previously been reported not to have ceiling effects but is limited in terms of assessments in the community (homes of older adults) because of space limitations and the need for a flight of stairs. The second PhD study involved modifying the CBMS to be suitable for assessment in homes (CBMS-Home) and identified good measurement properties (strong internal consistency, excellent test-retest reliability, lack of ceiling effects). Therefore, the CBMS-Home was selected as an outcome in the third study – a pre-post evaluation of a purpose-built Seniors Exercise Park intervention for older adults with mild balance dysfunction. Seniors Exercise Parks are a type of outdoor exercise park specifically developed to target and improve older adults' balance, strength, and function. Forty-six participants were recruited for an 18 week program with gradually reduced physiotherapist supervision, progressing to independent practice in a subsequent six weeks (to 24 weeks). The intervention was feasible and safe for the sample with mild balance dysfunction. Significant improvements were achieved on the CBMS-Home, as well as other physical performance and psychosocial outcomes at 18 weeks, with most gains being maintained through the independent practice period. A fourth qualitative study explored participant experiences with the Seniors Exercise Park intervention, identifying high levels of acceptability and perceived benefits associated with the program.

These studies were completed during the coronavirus pandemic in Australia. A final qualitative study explored the impacts of lockdown and other restrictions associated with the pandemic on the physical activity participation of older adults. Results highlighted that this sample of 17 people living in retirement villages who were physically active prior to the coronavirus pandemic remained physically active while in lockdown but in different ways and with reduced intensity and variety.

Overall, the findings in this thesis have contributed to validating a new assessment tool of physical performance (i.e., CBMS-Home) in higher functioning older adults for home or clinical settings, demonstrated the feasibility, safety and preliminary evidence of the effects of a novel outdoor exercise park intervention for older adults with mild balance dysfunction, and highlighted approaches used by older adults to maintain physical activity during the coronavirus pandemic.

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Dedication

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Abbreviations

CBMS	Community Balance and Mobility Scale
CBMS-Home	Modified Community Balance and Mobility Scale
CI	Confidence interval
COVID-19	Coronavirus
EQ-5D-5L	European Quality of Life Scale-5D-5L
ICC	Intraclass correlation coefficient
MDC_{95}	Minimal detectable change at 95% confidence interval
MET	Metabolic equivalent
OR	Odds ratio
PA	Physical activity
PAR-Q+	Physical Activity Readiness Questionnaire for Everyone
PASE	Physical Activity Scale for the Elderly
n	Number of participants
r	Pearson correlation coefficient
r_S	Spearman correlation coefficient
RCT	Randomised controlled trial
s-CBMS	Shortened version of the Community Balance and Mobility Scale
SD	Standard deviation
US	United States
WHO-5	Five-Item World Health Organisation Well-Being Index

Glossary of terms

Aerobic training (Aerobic exercise/activity, cardiovascular exercise/activity): Exercise that "includes forms of activity that are intense enough and performed long enough to maintain or improve an individual's cardiorespiratory fitness." (Physical Activity Guidelines Advisory Committee, 2018, pp. C-4). Examples of aerobic exercise are dancing, walking, and running (Physical Activity Guidelines Advisory Committee, 2018).

Balance: "The ability to maintain equilibrium while moving or while stationary." (Physical Activity Guidelines Advisory Committee, 2018, pp. C-19).

Balance training (Balance exercise/activity): Exercise that challenges postural control safely and can improve the ability of the individual to resist environmental or intrinsic forces that cause falls when sitting, standing, or walking if practiced regularly (Physical Activity Guidelines Advisory Committee, 2018). Examples of balance exercises are tandem walking and standing on one leg (Physical Activity Guidelines Advisory Committee, 2018).

Community Balance and Mobility Scale (CBMS): The CBMS is a 13-item physical performance test assessing different components of posture and movement using an eight metre walkway and a flight of stairs (Howe et al., 2006). The CBMS may be administered by a physiotherapist, exercise physiologist, exercise scientist or researcher.

Ceiling effect: A ceiling effect is a situation when the values acquired are at the upper limit of the scale during measurement (APA Dictionary of Psychology, 2021). It may suggest that the items on the measurement were not challenging enough for a group of people (Garin, 2014). For example, when assessing balance impairment if the tests were not challenging enough it may hide the balance impairment in higher functioning older adults, this in turn may limit recognition of their mild impairment and therefore they may not be referred for intervention (Balasubramanian, 2015).

Community-dwelling: People who live in the community, excluding residential aged care or nursing homes.

Coronavirus (COVID-19): COVID-19 is a disease caused by the novel coronavirus SARS-CoV-2 virus discovered in 2019 (World Health Organisation, 2021a). Most people with COVID-19 infections "will experience mild to moderate respiratory illness" (World Health Organisation, 2021a). Older adults with medical problems such as diabetes are at a higher risk of developing increasing severity of illness, hospitalisation or even death (World Health Organisation, 2021a).

Exercise: is a "subcategory of physical activity. Exercise is physical activity that is planned, structured, repetitive, and purposive" (Caspersen et al., 1985, p. 126) to maintain or improve health, physical performance or physical fitness (Physical Activity Guidelines Advisory Committee, 2018).

Falls: A fall is 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" (World Health Organisation, 2007, p. 1).

Flexibility training (Flexibility activity/exercise, stretching activity/exercise): Exercise that improves the range of motion around a joint (Physical Activity Guidelines Advisory Committee, 2018).

Impairment: "Impairment is an abnormality in bodily structure or function, in some cases caused by disease" (Hogan, 2019). Examples are pain or muscle weakness.

Light intensity activity: Activities between 1.6 to three METs, such as cooking activities or walking slowly at two miles per hour (3.2 kilometres per hour) or less (Physical Activity Guidelines Advisory Committee, 2018). The person would be able to sing a song while performing the activity (Physical Activity Guidelines Advisory Committee, 2018). The person would not sweat or experience shortness of breath (National Academy of Sports Medicine, 2022).

Metabolic equivalent (MET): "A MET is a unit that indicates the energy cost of activities (Physical Activity Guidelines Advisory Committee, 2018).

Mild balance dysfunction: Balance performance varies across a continuum, from excellent balance performance to very poor balance performance. The term "mild balance dysfunction" has been used to describe people with balance performance towards the upper end of the balance performance spectrum, but who are starting to have indications that their balance is not as good as it was previously, and who, when assessed, do have a measurable balance impairment. There are several definitions of mild balance dysfunction in the literature. In this thesis, older adults were determined as presenting with mild balance dysfunction in research terms, if the values of either or both the Functional Reach Test and Step Test were below the cut-off scores determined for their age (Williams et al., 2015).

Mobility: is the ability of the person to move about independently in their environment (i.e., on their own or using an assistive device or using alternate forms of transport such as a personal vehicle) within and beyond their home to the community (Webber et al., 2010) and can be influenced by factors such as changes in physical health and familiarity with the environment (Franke et al., 2017).

Moderate intensity activity: Physical activity that requires three to less than six METS (Physical Activity Guidelines Advisory Committee, 2018). It is an activity that would cause a person to break out in a sweat and experience an increase in heart rate (Centres for Disease Control and Prevention, 2018). The person would be able to talk, but not able to sing a song (Centres for Disease Control and Prevention, 2018). Examples of moderate intensity activity are vacuuming, and walking briskly at three to four miles per hour (4.8 to 6.4 kilometres per hour) (Physical Activity Guidelines Advisory Committee, 2018).

Modified Community Balance and Mobility Scale (CBMS-Home): CBMS-Home is a modified version of the CBMS assessing different components of posture and movement to be suitable for use within most homes (e.g. use of a shorter walkway (i.e., four metres) (Ng, Hill, Jacques, et al., 2021). It consists of eight items from the original CBMS and four modified items (i.e., 'walk and talk', 'walk, talk and carry', 'forward to backward walk' and 'run with a controlled stop') (Ng, Hill, Jacques, et al., 2021).

Multi-modal training (multi-modal exercises, multi-modal intervention, multi-component training or multi-component exercise): combines two or more types of exercise focused on improving muscle strength, endurance / cardiovascular, flexibility, and balance outcomes within a single session (Liu et al., 2017).

Outdoor exercise parks: Installation of outdoor exercise equipment spread along a path or clustered together in outdoor public spaces or parks (City of Sydney, 2020).

Pandemic: is defined as "an outbreak of a disease that occurs over a wide geographic area (such as multiple countries or continents) and typically affects a significant proportion of the population" (Merriam Webster Dictionary, 2021).

Physical activity: is defined as “any bodily movement produced by skeletal muscles that result in energy expenditure” (Caspersen et al., 1985, p. 126).

Researcher: Throughout this thesis, this term (the researcher) is used to refer to the PhD candidate, and first author of the published papers, and the person who collected data for all of the studies.

Resistance training (resistance activity/exercise or muscle strengthening activity/exercise): Exercise that “maintains or improves muscular strength (how much resistance can be overcome), endurance (how many times or for how long resistance can be overcome), or power (how fast can the resistance be overcome)” (Physical Activity Guidelines Advisory Committee, 2018, pp. C-5). Examples of muscle strengthening exercises include the use of equipment such as elastic (thera) bands and free weights, as well as everyday activities, such as climbing stairs or standing up from a chair (Physical Activity Guidelines Advisory Committee, 2018).

Retirement village: A retirement village is a community of homes designed for people (aged over 55 years) who are active and independent in their daily lives (McCrea & Stimson, 2004; Property Council of Australia, 2014) and often provide communal facilities, such as gymnasiums or halls and services for their residents (Hu et al., 2017).

Sedentary activity: Activities that require less than 1.5 METS, such as watching television or sitting (Physical Activity Guidelines Advisory Committee, 2018).

Seniors Exercise Park: consists of “kits” of specialised outdoor exercise equipment designed and built specifically to improve the physical performance (e.g., balance, muscle strength) of older adults. Seniors Exercise Parks are manufactured by Lappset, Lark Industries Pty Ltd (larkindustries.com.au).

Vigorous intensity activity: Activities that require six or greater METS, such as participating in an aerobics class, brisk walking at 4.5 to five miles per hour (7.2 to eight kilometres per hour), and carrying heavy loads (Physical Activity Guidelines Advisory Committee, 2018).

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Chapter 1 : Introduction

1.1 Statement of the problem

Regular participation in physical activity helps maintain and improve the health and well-being of older adults (Daskalopoulou et al., 2017; Etnier et al., 2019; Soares-Miranda et al., 2016) and reduces the risk of adverse events (e.g., falls) (Sherrington, Fairhall, Kwok, et al., 2020) and chronic conditions (Macera et al., 2017; Soares-Miranda et al., 2016). However, participation rates in physical activity remain low amongst this population (Australian Institute of Health and Welfare, 2020; Bennie et al., 2017; Canadian Community Health Survey, 2021; Keadle et al., 2016). Current Australian Physical Activity Guidelines recommend that older adults: (1) should accumulate 30 minutes of moderate intensity physical activity on most or every day of the week, and (2) it should include multi-modal activities (Sims et al., 2010). However, studies have shown that 73.9% of older adults do not engage in adequate physical activity (Australian Institute of Health and Welfare, 2020), 94% do not perform any balance training (Merom, Pye, et al., 2012), and 87.6% (aged 65 to 74 years) and 92.4% (75 years or older) do not participate in muscle strengthening activities regularly (Bennie et al., 2016). Therefore, there is a need to explore further how to promote regular physical activity among older adults and potentially consider using novel equipment or activity options to promote ongoing physical activity to improve or maintain health and well-being. Outdoors Seniors Exercise Parks may be one novel type of exercise equipment to encourage older adults to be more physically active, that is explored in this thesis.

The primary aims of this thesis were to: evaluate the use and effects of outdoor exercise parks on physical activity, physical function, psychosocial outcomes, and quality of life among older adults; evaluate the measurement properties of a modified assessment tool

(Community Balance and Mobility Scale (CBMS-Home)) developed for settings with limited space that discriminates performance of those with relatively good mobility (similar to the original Community Balance and Mobility Scale (CBMS)), explore the impact of coronavirus (COVID-19) on physical activity participation among older adults living in retirement villages; and extend existing research on the use of Seniors Exercise Parks to identify its feasibility, safety, and effects among older adults with mild balance dysfunction.

1.2 Thesis overview

This hybrid thesis consists of nine chapters, including four published (accepted) papers and one paper currently under review. Chapter 1 is the Introduction Chapter.

Chapter 2: Literature review

This chapter provides the background on the ageing population, physical activity, and the COVID-19 pandemic. This section also reviews the literature on the Community Balance and Mobility Scale, older adults with mild balance dysfunction, Seniors Exercise Parks, and physical activity participation of older adults during the COVID-19 pandemic.

Chapter 3: Methods

This chapter outlines methodological information used for the studies in this thesis that could not be included within each journal article due to word count restrictions. It includes a detailed explanation about recruitment, inclusion and exclusion criteria, outcome measures and measurement procedures.

Chapter 4: Effectiveness of outdoor exercise parks on health outcomes in older adults − A mixed-methods systematic review and meta-analysis

Outdoor exercise parks (i.e., outdoor exercise equipment) located outdoors or in public spaces may provide opportunities for increased engagement in physical activity for older adults. Previous systematic reviews suggest that outdoor exercise parks may improve the physical activity and health of the users (Jansson et al., 2019) and provide opportunities for social interaction, and are beneficial to health (Lee et al., 2018). However, both reviews focused on the effects of health outcomes and user characteristics of outdoor exercise parks across all age groups. What is less clear is the use and effectiveness of outdoor exercise parks on health outcomes among older adults. Synthesising the evidence about the use of outdoor exercise parks could help inform best practices regarding outdoor exercise parks use as a physical activity intervention among older adults.

This chapter is presented as a published paper and reports the findings of the systematic review on the use and effects of outdoor exercise parks on physical activity, physical function, psychosocial outcomes, and quality of life in older adults. The results of the meta-analysis, limitations and future recommendations are also discussed.

Chapter 5: Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment

Several widely used balance and mobility tests are limited by ceiling effects in higher functioning older adults. Ceiling effects may hide early balance problems (Balasubramanian, 2015; Bergquist et al., 2019) and could delay older adults' accessing interventions to improve their balance and mobility. The Timed Up and Go Test, Berg Balance Scale, Performance Oriented Mobility Assessment, Dynamic Gait Index, and

Short Physical Performance Balance Battery are commonly used balance and mobility tests that are prone to ceiling effects in higher functioning older adults (Bergquist et al., 2019; Boulgarides et al., 2003; Middleton & Fritz, 2013; Pardasaney et al., 2012). Higher functioning older adults who lead an active lifestyle are at an increased risk of exposure to balance challenging situations, and their risk of falls may be higher (Dionyssiotis, 2012; Weber et al., 2018). Their risk of injuries from falls may also be higher (Kelsey et al., 2012; Speechley & Tinetti, 1991) and is likely associated with their faster gait speed (Kelsey et al., 2012) and higher momentum at impact if a fall does occur. Therefore, this emphasises a need to expand and validate existing or new challenging balance and mobility tests for older adults who are higher functioning and active.

The CBMS is a valid and reliable scale with no ceiling effects in higher functioning older adults (Balasubramanian, 2015; Weber et al., 2018). However, its practical use is limited by the requirement of a long walkway (i.e., eight metres) and stairs (i.e., a minimum of eight steps), which may not be available in settings with limited space (e.g., homes, clinics). Therefore, this study aimed to address this gap in clinical practice by evaluating a modified version of the CBMS (CBMS-Home), (1) by reducing the length of the walkway required for several items to four meters (down from eight metres), (2) removing the item ‘descending stairs’ and (3) modifying the scoring criteria for four of the items (i.e., by halving the duration to complete the items on the CBMS) for it to be feasible for use within an older adult’s home.

This chapter is presented as a published paper and reports the findings, including measurement properties of the CBMS-Home for settings with limited space (e.g., home). The findings of this study were used to determine the suitability of CBMS-Home for the pre-post intervention study (Chapter 6).

Chapter 6: Seniors Exercise Park program for older adults with mild balance dysfunction − A feasibility study

Some outdoor exercise parks are built especially for older adults, known as Seniors Exercise Parks (Sales et al., 2015) (See Figure 1.1). An advantage of Seniors Exercise Parks is the convenience and availability of multi-modal exercise equipment (e.g., flexibility, strength, mobility, and balance) for training in a single location. In addition, Seniors Exercise Parks are unique because they include balance training equipment that other outdoor exercise parks usually do not have.

Figure 1.1. Seniors Exercise Park at a retirement village

A population that could benefit from using a Seniors Exercise Park are older adults with mild balance dysfunction. Older adults with mild balance dysfunction usually do not consult health professionals often (Williams et al., 2015) because of the lack of knowledge and awareness about the programs available to help them improve their balance or ascribing their sense of reduced balance to age-related changes (Yang et al., 2011). In addition, most balance assessments are not sensitive enough to detect mild balance impairments. Older adults with mild balance dysfunction demonstrated physical performance improvements after undergoing balance, resistance, and walking training at home (Williams et al., 2015; Yang et al., 2012). However, these studies were centred on the participants practicing their exercises at home (Williams et al., 2015; Yang et al., 2012). What is not known are the effects of older adults with mild balance dysfunction participating in a group-based intervention using a Seniors Exercise Park. Therefore, this pre-post intervention study aimed to fill these identified research gaps and add to the emerging literature by (1) evaluating a model of gradual reduction in supervision and progressing to independent Seniors Exercise Park use among older adults with mild balance dysfunction, and (2) utilising an outcome measure, the CBMS-Home, that does not have a ceiling effect (based on the results of Chapter 5).

This chapter is presented as a published paper and discusses the findings of the Seniors Exercise Park program in older adults with mild balance dysfunction.

Chapter 7: Experiences of older adults with mild balance dysfunction who participated in a supervised Seniors Exercise Park program progressing to independent practice

Previous qualitative studies have explored the feasibility and acceptability of Seniors Exercise Parks (Sales et al., 2018) and factors that supported adherence among older adults (Levinger, Dunn, et al., 2021). Both these studies provided information on the acceptability of Seniors Exercise Parks and how to make the program successful with a sample of older adults who were relatively well and independent.

A previous qualitative study that explored the experiences of older adults with mild balance dysfunction reported that they recognised the importance of engaging in physical activity and the convenience of exercising on their own at home (Meyer et al., 2016). Some of the participants interviewed in the Williams et al. (2015) study identified the length of the program (i.e., 24 weeks) and lack of time as barriers to home training (Meyer et al., 2016). Older adults with mild balance dysfunction may have different views about engaging in group-based Seniors Exercise Park training compared to home-based training, and factors influencing participation may be unique to this population. To date, no studies have investigated the experiences of gradual reduction of supervised Seniors Exercise Park group training or the factors that influence Seniors Exercise Park supervised and independent training among older adults with mild balance dysfunction.

This chapter discusses the experiences of older adults with mild balance dysfunction who participated in the supervised Seniors Exercise Park program with a gradual reduction of supervision, progressing to independent training. In addition, the enablers and barriers to their participation were reported.

Chapter 8: Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic

The first COVID-19 lockdown occurred in March 2020 throughout Australia. The COVID-19 pandemic lockdown and restrictions prevented the start of the Seniors Exercise Park studies (described in Chapters 6 and 7) for six months. During these six months, an opportunity arose to conduct an additional qualitative study to explore the impact of COVID-19 on older adults' physical activity participation.

The coronavirus was a serious respiratory infection and affected many countries globally (Cowling & Aiello, 2020; Lee, 2020; Malik et al., 2020). A series of measures were implemented, such as physical distancing, social isolation, and sudden lockdowns to stop and limit the spread of the COVID-19 infection (Cowling & Aiello, 2020; Wilder-Smith & Freedman, 2020). Studies have shown that older adults living in the community performed shorter durations of physical activity (Yamada et al., 2020) and reduced their group-based physical activity participation during COVID-19 (Goethals et al., 2020). These findings suggest that older adults adjusted their physical activity participation, and these changes may have increased their sedentary behaviour. Sedentary behaviour increases the risk of major chronic diseases (Fox et al., 2014) and depression (Huang et al., 2020).

Some older adults choose to live in a retirement village because they feel the environment promotes social opportunities, safety, and provides them with access to facilities (e.g., gym, swimming pool) (Crisp et al., 2013; Gardner et al., 2005). During the COVID-19 lockdown, many leisure (e.g., line dancing) and sports activities (e.g., croquet) run within or external to the retirement village were cancelled, and leisure or fitness facilities were shut down. This may have caused a decline in physical activity engagement among older adults, including those living in retirement villages. Any reduction in physical activity could have negative effects on the function and health of older populations during this pandemic. There is limited research exploring the experiences and perceptions of physical activity participation among older adults during the COVID-19 pandemic, particularly for those living in a retirement village.

This chapter is presented as a published paper and explores older adults' physical activity experiences during the COVID-19 lockdown.

Chapter 9: Discussion and conclusion

This chapter summarises and synthesises the overall findings of the series of studies in this thesis in the context of relevant literature. The practical implications, strengths and limitations of the series of studies, and future recommendations for research in this area are also discussed.

Appendices

This section consists of material that supplements the information presented in the respective chapters, such as information regarding ethics approval, participant consent forms, participant information sheets, copyright permissions, questionnaires and handouts used during data collection, and author contribution statements.

Chapter 2 : Literature review

Chapter outline

This chapter provides an overview, summary, and evaluation of research in physical activity, balance and mobility assessments (limited to clinical tests only, description about laboratory tests were excluded), mild balance dysfunction, and outdoor exercise parks. The studies in the thesis were conducted during the peak of the COVID-19 pandemic in Australia, whereby data collection was not possible for six months due to government restrictions. During these six months, an additional study exploring older adults' physical activity experiences during the pandemic was included. Therefore, a section regarding the literature on COVID-19 is described.

2.1 The ageing population

The number of people aged 65 years and over is rising rapidly. In 2020, one in six or 16% (4.2 million) of adults were 65 years and over in Australia (Australian Institute of Health and Welfare, 2021a). This percentage could rise to 23% (11.3 million) by 2066 (Australian Bureau of Statistics, 2018; Australian Institute of Health and Welfare, 2021a). The rise in the size of the older population is also projected worldwide. In 2019, one in 11 people were aged 65 years and over, and this is projected to increase to one in six people by 2050 worldwide (United Nations, 2019). By 2050, the ageing population would have doubled from 703 million to 1.5 billion globally (United Nations, 2019).

Life expectancy beyond 65 years of age is improving, and Australia has one of the highest life expectancies in the world, at 82.8 years (Australian Institute of Health and Welfare, 2021c). Increased life expectancy could be due to improved medical care and healthier lifestyles (Brown, 2015). The life expectancy in Australia is estimated to rise further to 88.9 years by 2050 (United Nations, 2019). Globally, an older person could live to 82 years currently and 84 years by 2045-2050 (United Nations, 2019). The life expectancy of people aged 65 in Australia is slightly higher when compared to the global rates of life expectancy at present.

A rise in life expectancy means people will live longer, but this increase does not mean a better quality of life for older adults. Increased age is often associated with chronic diseases such as cardiovascular disease, musculoskeletal disease, cancer, and respiratory disease (Brown, 2015; Prince et al., 2015). In addition, a decline in balance, mobility, and musculoskeletal function (such as lower body muscle strength and balance) as people grow older (Butler et al., 2009; Cruz-Jimenez, 2017; Nolan et al., 2010) may increase their risk of falls (Ambrose et al., 2013; Blain et al., 2016), and admission into an aged care facility (i.e., nursing home) (Cegri et al., 2020; Guralnik et al., 1994). A modifiable risk factor for chronic disease and reductions in physical performance is physical inactivity (Durstine et al., 2013; González et al., 2017; Warburton et al., 2006; World Health Organisation, 2020b). Therefore, physical activity participation is critical to help older adults stay healthy, maintain their function, and live independently in the community.

2.2 Definition of physical activity and exercise

Physical activity is defined as “any bodily movement produced by skeletal muscles that results in energy expenditure” (Caspersen et al., 1985, p. 126), such as household chores and walking to the shop. Exercise is a “subcategory of physical activity that is planned, structured, repetitive, and purposive” (Caspersen et al., 1985, p. 126), such as lifting weights in a gym or performing home exercises recommended by a physiotherapist. Therefore, exercise is different from physical activity due to the structure, intensity, and planned repetition to achieve a goal, but both can result in important health benefits.

2.3 Why is physical activity important for older adults?

Increasing physical activity participation is important for older adults because of its many health benefits. These health benefits summarised by previous literature include to:

- Minimise risk of coronary heart disease (Macera et al., 2017; Soares-Miranda et al., 2016).
- Improve lipid profile (Piercy et al., 2018; Taylor et al., 2004; Vogel et al., 2009).
- Minimise risk of type two diabetes (Macera et al., 2017; Taylor et al., 2004; Vogel et al., 2009).
- Minimise risk of stroke (Soares-Miranda et al., 2016; Vogel et al., 2009).
- Minimise risk of and control hypertension (Diaz & Shimbo, 2013; Taylor et al., 2004; Vogel et al., 2009).
- Minimise risk of breast and colon cancer (Kyu et al., 2016; Taylor et al., 2004; Vogel et al., 2009).
- Reduce the risk of falls (Dipietro et al., 2019; Sherrington, Fairhall, Kwok, et al., 2020; Taylor et al., 2004; Vogel et al., 2009).
- Reduce the risk of cognitive decline (Etnier et al., 2019; Vogel et al., 2009) and dementia (Macera et al., 2017; Paterson & Warburton, 2010; Vogel et al., 2009).
- Improve physical function (Dipietro et al., 2019; Paterson & Warburton, 2010; Piercy et al., 2018).

2.4 Physical activity recommendations for older adults

There are numerous physical activity guidelines published for older adults (aged 65 years and older), such as by the World Health Organisation (World Health

Organisation, 2020b) and the Australian Government (Sims et al., 2010; Sims et al., 2006). The purpose of these physical activity guidelines is to provide guidance on the minimum levels of physical activity participation needed for good health and to reduce health risks. The number of recommendations, wording, and phrasing differs between the World Health Organisation and Australian Government guidelines (See Table 2.1). The similarities and differences across the guidelines are described below:

- Both guidelines emphasise the importance of participating in regular physical activity and encourage older adults to do multi-modal activities.
- The World Health Organisation guidelines included details on intensity, frequency of specific type of exercise (e.g., muscle strengthening and functional balance activities) and encouraged more than the minimum amount of time prescribed, whereas the Australian guidelines recommended the minimum amount of time to be physically active.
- Older adults were advised to replace sedentary behaviour with any intensity physical activity and to engage beyond the recommended levels of physical activity (World Health Organisation, 2020b). There were no recommendations regarding sedentary behaviour in the Australian guidelines.
- The Australian guidelines included recommendations for older adults who have performed a lifetime of vigorous activities and older adults who have stopped or about to start a new physical activity. These recommendations were not emphasised in the World Health Organisation guidelines.

Table 2.1. Physical activity recommendations for older adults

Australian guidelines	World Health Organisation guidelines
Consist of five recommendations	Consists of five recommendations for physical activity and two recommendations for sedentary behaviour
1. Some form of physical activity should be performed regardless of health conditions, weight, or age	1. Older adults should perform physical activity consistently
2. Accumulate at least 30 minutes of moderate intensity physical activity on most, or ideally all, days	2. Older adults should do at least 150-300 minutes of moderate intensity physical activity; or 75-150 minutes of vigorous intensity physical activity; or similar combination of both intensity activity weekly to gain large benefits
3. Older adults embarking on a new physical activity or who have stopped physical activity should start at a comfortable level of intensity and increase the frequency, type, and amount gradually	3. To perform muscle strengthening activities at moderate or greater intensity involving all major muscle groups on 2 or more days a week
4. To perform a range of physical activities that include balance, fitness, strength, and flexibility	4. To perform a range of activities emphasizing strength and balance training at moderate or greater intensity, on 3 or more days a week to prevent falls and improve function
5. If older adults have enjoyed a lifetime of vigorous physical activity, continue in a manner suited to their capability	5. Older adults may increase beyond 300 minutes of moderate intensity; or 150 minutes of vigorous intensity physical activity to gain additional health benefits
	6. To limit the amount of time spent on sedentary behaviour, and to replace sedentary time with physical activity
	7. Older adults should aim to do more than the recommended levels of physical activity to help reduce the detrimental effects of high levels of sedentary behaviour on health

Note. Adapted from World Health Organisation. (2020). WHO Guidelines on Physical Activity and Sedentary Behaviour. https://www.who.int/publications/i/item/9789240015128; and Sims, J., Hill, K., Hunt, S., & Haralambous, B. (2010). Physical activity recommendations for older Australians. *Australasian Journal on Ageing*, *29*(2), 83. https://doi.org/10.1111/j.1741-6612.2009.00388.x.

2.5 Are older adults doing enough physical activity?

In a pooled analysis of surveys from 168 countries, 72.5% of people of all ages globally have been estimated to meet the required minimum dosage of physical activity (Guthold et al., 2018). A systematic review reported a range of 2.4% to 83% of older adults meeting the required dosage of physical activity across the world (Sun et al., 2013). Men were likely to be more physically active than women (Australian Institute of Health and Welfare, 2020; Hallal et al., 2012; Keadle et al., 2016; Li et al., 2017).

The percentage of older adults engaging in adequate physical activity, balance and muscle strengthening activities differed across the world (See Table 2.2). The percentage of older adults engaging in muscle strengthening and balance activities was lower than for physical activity in general. Australia had one of the lowest percentages of older adults who were sufficiently active compared to other countries. Therefore, exploring novel types of physical activity that may encourage more older adults to be physically active and meet the Australian physical activity guidelines is important.

Table 2.2. Older adults engaging in sufficient physical activity, muscle strengthening and balance activities across the world

Country	Percentage (%) of older adults engaging in physical activity, duration, and intensity of physical activity	Percentage (%) of older adults engaging in muscle strengthening activities and number of days a week	Percentage (%) of older adults engaging in balance activities and number of days a week
Australia	26.1%, 30 minutes of moderate intensity physical activity ≥ 5 days per week (Australian Institute of Health and Welfare, 2020)	15.6%, (Australian Institute of Health and Welfare, 2020)	6%, (Merom, Pye, et al., 2012)
Canada	40.3%, 150 minutes of moderate to vigorous intensity physical activity (Canadian Community Health Survey, 2021)	32.5%, ≥ 1 day a week (Copeland et al., 2019)	35.6%, ≥ 1 day a week (Russell et al., 2017)
United States of America	40.5%, 150 minutes of moderate intensity or 75 minutes of vigorous intensity physical activity per week (US Department of Health and Human Services, 2021)	18.6%, ≥ 2 days a week (US Department of Health and Human Services, 2021)	41%, 1 day a week (Hyde et al., 2021)
Europe	87.5% (aged 55 years or older), moderate or vigorous intensity physical activity (Gomes et al., 2016)	12.2%, ≥ 2 days a week (Bennie et al., 2020)	Finland: 4.4%, 2 days a week (Bennie et al., 2017) Scotland: 20%, 2 days a week (Strain et al., 2016)

2.6 Enablers and barriers to physical activity

Since 2011, ten systematic review studies have identified enablers and barriers to physical activity amongst older adults. Table 2.3 outlines the aims, context, number, and type of studies included, participants' age, setting, and theoretical framework of the systematic reviews. Eight of the ten systematic reviews used a theoretical framework for their analysis.

Four studies used the Socioecological Model (Baert et al., 2011; Burton, Farrier, et al., 2017; Franco et al., 2015; Yarmohammadi et al., 2019). The other systematic reviews used different models: The Newell Model (Blankley et al., 2020), Theory Driven Thematic Framework Analysis (Spiteri et al., 2019), Meta-ethnography Analysis (Ige-Elegbede et al., 2019), and Framework Analysis (Horne & Tierney, 2012). Enablers and barriers have been identified for specific age groups (i.e., 50 to 64, 65 to 70 and 80 years and over) (Spiteri et al., 2019), specific population groups such as South Asian older adults (Yarmohammadi et al., 2019), black minority ethnic backgrounds living in the United Kingdom (Ige-Elegbede et al., 2019), older men (Blankley et al., 2020), and different types of exercise, such as resistance training (Burton, Farrier, et al., 2017). Therefore, similarities and differences may exist between and within population groups.

Table 2.3. Systematic reviews of enablers and barriers to older people being physically active

Reference	Study aims	Context	Number and type of studies included	Participants age and setting	Theoretical framework
Blankley et al. (2020)	To investigate the facilitators and barriers in older men to physical activity participation	Physical activity	9; qualitative, cross sectional and RCT	Age ≥ 60 years; setting = community	Newell model
Spiteri et al. (2019)	To identify the barriers and enablers of middle-aged (50-64 years) and older (65-70 years) people to physical activity participation	Physical activity	55; qualitative and quantitative research	Age 50-70 years; setting = community	Theory driven thematic framework analysis
Ige-Elegbede et al. (2019)	To identify the barriers and facilitators of physical activity from black minority ethnic backgrounds in the United Kingdom	Physical activity	10; qualitative research	Age > 50 years; setting = community	Meta-ethnography analysis
Yarmohammadi et al. (2019)	To review the barriers and enablers to physical activity in older adults in Iran and other countries	Physical activity	34; qualitative and quantitative research	Age > 60 years; setting = community	Socioecological model
Cavill and Foster (2018)	To identify the barriers and enablers for older adults participating in balance and muscle strengthening activities	Muscle strengthening and balance activities	17; qualitative, systematic reviews, expert consensus.	Age = 40-64 and ≥ 65 years; setting = community, nursing homes	Not reported
Burton, Farrier, et al. (2017)	To identify the barriers and enablers for older adults participating in muscle strengthening activities	Muscle strengthening activities	14; qualitative research, RCTs, uncontrolled evaluations, quantitative research, mixed methods	Age > 60 years; setting = community	Socioecological model

Table 2.3. Continued

Reference	**Study aims**	**Context**	**Number and type of studies included**	**Participants age and setting**	**Theoretical framework**
Sandlund et al. (2017)	To explore the gender views or preferences regarding adherence and exercise uptake to prevent falls	Exercise to prevent falls	25; qualitative and quantitative research, mixed methods	Age ≥ 60 years; setting = community and nursing homes	Not reported
Franco et al. (2015)	To identify barriers and facilitators to physical activity participation	*Structured exercise programs, #other forms of physical activity or combination of both	132; qualitative research	Age ≥ 60 years; setting = community, long term care facilities, assisted living facilities and hospitals	Socioecological model
Horne and Tierney (2012)	To explore the experiences of South Asian older adults and understand reasons for exercise and physical activity participation	Exercise, physical activity	11; qualitative research	Age ≥ 60 years; setting = community, sheltered housing, hospitals, clinics	Framework analysis
Baert et al. (2011)	To identify enablers and barriers for physical activity in people aged 80 years and over.	Physical activity	44; qualitative and quantitative	Age > 79 years; setting = community, independent living communities, patients admitted to a geriatric rehabilitation unit, long term care facility or nursing homes	Socioecological model

Note. RCTs = Randomised controlled trials.

*Structured exercise programs = Exercise programs including different type of exercise.

#Other forms of physical activity = Leisure activities, household activities, walking for transport or leisure.

2.6.1 Enablers to physical activity

Numerous studies have reported factors that motivate older adults to be physically active. The most common enablers to physical activity were:

- Physical health benefits, maintaining independence and improved physical function (Baert et al., 2011; Blankley et al., 2020; Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Franco et al., 2015; Horne & Tierney, 2012; Ige-Elegbede et al., 2019; Sandlund et al., 2017; Spiteri et al., 2019; Yarmohammadi et al., 2019).
- Psychological benefits, such as improved mental health, well-being and enjoyment while doing physical activity (Baert et al., 2011; Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Franco et al., 2015; Horne & Tierney, 2012; Ige-Elegbede et al., 2019; Yarmohammadi et al., 2019).
- Social factors, including encouragement and social support from family or friends (Baert et al., 2011; Blankley et al., 2020; Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Franco et al., 2015; Horne & Tierney, 2012; Ige-Elegbede et al., 2019; Sandlund et al., 2017; Spiteri et al., 2019; Yarmohammadi et al., 2019).
- The availability of instruction and supervision to support confidence and correct performance of the activities (Baert et al., 2011; Cavill & Foster, 2018; Franco et al., 2015; Horne & Tierney, 2012; Ige-Elegbede et al., 2019; Sandlund et al., 2017; Yarmohammadi et al., 2019).

Specific enablers were identified for the type of exercise, age, and gender by some of these authors. Burton, Farrier, et al. (2017) identified reduced risk of falls, improved muscle tone, and improved alertness and concentration as enablers to participating in resistance exercise. Retirement was a chance to be active for adults aged 65 to 70 years (Spiteri et al., 2019). Enablers for men to engage in physical activity included setting goals, engaging in activities that made them feel important, maintaining independence with household chores, and competitive activities, such as golf (Blankley et al., 2020).

2.6.2 Barriers to physical activity

Engagement in physical activity is a complex and dynamic process influenced by many factors. Identifying and understanding the barriers to physical activity can help identify strategies to encourage physical activity engagement and maintenance in older adults. Common barriers to physical activity were:

- Poor health, which limited the older adults' ability to participate in physical activity (Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Ige-Elegbede et al., 2019; Sandlund et al., 2017; Spiteri et al., 2019).
- Lack of motivation (Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Sandlund et al., 2017; Spiteri et al., 2019; Yarmohammadi et al., 2019).
- Lack of time due to other commitments, such as family, volunteer work or paid employment (Baert et al., 2011; Blankley et al., 2020; Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Franco et al., 2015; Sandlund et al., 2017; Spiteri et al., 2019).
- Lack of knowledge about physical activity (i.e., how to be active and where to go to be active) (Baert et al., 2011; Blankley et al., 2020; Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Horne & Tierney, 2012; Sandlund et al., 2017; Spiteri et al., 2019).
- Lack of support from family and friends (Baert et al., 2011; Blankley et al., 2020; Burton, Farrier, et al., 2017; Cavill & Foster, 2018; Franco et al., 2015; Horne & Tierney, 2012; Sandlund et al., 2017; Spiteri et al., 2019).

Some barriers were specific to the type of activity (e.g., resistance), gender and population (e.g., South Asian descent). Appearance, such as "looking too muscular", and perceived risk of sustaining a stroke, death, or heart attack, was a barrier for some older adults engaging in resistance training (Burton, Farrier, et al., 2017, p. 317). In contrast, social stigma, such as being perceived as “a faller” or “old”, fear of falls, and denying the risk of falls were specific barriers for old adults undertaking falls prevention activities (Cavill & Foster, 2018, p. 112). Performing non-meaningful activity appeared to be a barrier specifically to men (Blankley et al., 2020). South Asian and black minority older adults cited communication difficulties, fatalism (i.e., a feeling that having a disease is predestined), and the lack of gender-specific classes or spaces were barriers to physical activity (Horne & Tierney, 2012; Ige-Elegbede et al., 2019). In summary, many factors influence the physical activity behaviour of older adults and could differ from individual to individual, within or between population groups.

2.7 Retirement villages and their residents

Older adults in Australia have multiple housing choices, ranging from private residences to aged care facilities (Australian Institute of Health and Welfare, 2021b). Most older adults prefer to stay in their place of residence (i.e., their home) (Mulliner et al., 2020), others may relocate to a smaller place over time, a proportion may move into a retirement village (Crisp et al., 2013; McCrea & Stimson, 2004) and another smaller percentage, with substantial physical and/or cognitive impairment live in residential aged care facilities (Gibson, 2020).

A retirement village is a community of homes designed for people (aged over 55 years) who are active and independent in their daily lives (McCrea & Stimson, 2004; Property Council of Australia, 2014). Different types of accommodation are available, such as individual living units (villas or apartments) and group housing (Holt et al., 2016).

Retirement villages often provide communal facilities, such as gymnasiums or halls and services for their older residents (Hu et al., 2017).

Recent data indicated that 11% of adults aged 65 years and over were living in retirement villages in Australia (Australian Institute of Health and Welfare, 2018). It is predicted that the demand for living in a retirement village will increase, partly due to the rise in Australia's ageing population (Hu et al., 2017). Compared to other cities in Australia, Perth has the highest percentage (7.2%) of older adults living in retirement villages (Hu et al., 2017).

Living in a retirement village may be a feasible residential arrangement for some older adults because the environment encourages independence (Crisp et al., 2013; Gardner et al., 2005), promotes social interaction, improves quality of life and security (Gardner et al., 2005), and provides easy access to medical facilities, assisted living facilities, and outdoor living areas (Crisp et al., 2013). Although many retirement villages provide physical activity programs (e.g., line dancing, fitness classes, bowling green) and facilities (e.g., gym, swimming pool), the weekly utilisation rate of physical activity facilities and attendance rates of physical activity programs was low, at 50% (Holt et al., 2016). In a cross sectional study of 323 residents from 32 retirement villages in Western Australia, only 27.1% of the residents were physically active (i.e., met the minimum of 150 minutes of moderate to vigorous intensity physical activity) when measured using accelerometers (Nathan et al., 2014).

Walking was the preferred type of physical activity among residents living in retirement villages (Miller & Buys, 2007; Nathan et al., 2014) and across Australia in general (Merom, Pye, et al., 2012). There are many health benefits associated with walking (Kelly et al., 2018; Lee & Buchner, 2008), such as improved cardiovascular fitness and promotion of mental health (Kelly et al., 2017). However, it may not protect against health conditions, such as falls (Sherrington, Fairhall, Wallbank, et al., 2020; Sherrington et al., 2019; Voukelatos et al., 2015). In addition, residents often did not participate in adequate multi-modal activities (i.e., balance, strength, flexibility) (Nathan et al., 2014), with one study reporting that only 2.6% of older adults participated in multi-modal activities (Merom, Cosgrove, et al., 2012) that were essential for good health (Bouaziz et al., 2016; Sims et al., 2010; World Health Organisation, 2020b). Hence, there is a need to encourage multi-modal activities and adequate intensity of physical activity among retirement village residents and community-dwelling older adults by providing enjoyable and suitable multi-modal physical activity programs that are easy to access.

2.8 Falls

Falls are 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” (World Health Organisation, 2007, p. 1). Falls are common in older adults. One-third of people aged 65 years and over living in the community fall each year in Australia (Dolinis et al., 1997; Gill et al., 2005; Morris et al., 2004), and this proportion is similar in many other countries (Cigolle et al., 2015; Kłak et al., 2017; Kojima et al., 2008; Orces, 2013; Pasquetti et al., 2014; Talbot et al., 2005).

Older adults require good vestibular and sensorimotor function, including adequate vision, reaction time, proprioception, and muscle strength to remain upright in the event of a trip (Sherrington & Tiedemann, 2015; Wallmann, 2009) and slip (Lockhart et al., 2005; Paraskevoudi et al., 2018). Falls happen when the function of these physiological components are affected by ageing, physical inactivity, medications, or diseases (Sherrington & Tiedemann, 2015), or when these systems are inadequate to maintain stability when balance has been substantially challenged (e.g., uneven, slippery surface, over reaching).

Some of the consequences of falls include injuries, concern about falling, reduced mobility and activity levels, and reduced quality of life (Tiedemann & Sherrington, 2017) with associated effects on the health care system, including health care expenditure and burden of disease (Davis et al., 2010; Florence et al., 2018). Seventy five percent of injuries leading to hospitalisation were caused by falls among older adults (Australian Institute of Health and Welfare, 2019). The most common areas of fall injury were to the head (26%), thigh and hip (22%) in Australia (Australian Institute of Health and Welfare, 2019). Hip fractures were one of the most frequent injuries of the lower extremities sustained after a fall (Australian Institute of Health and Welfare, 2019). Older adults who sustain a hip fracture can experience serious consequences (Tang et al., 2017). Most do not return to their previous functional level (Lin & Chang, 2004; Tang et al., 2017), and 37% may die after hip fracture (Tang et al., 2017). Given the potentially serious consequences of falls, understanding the risk factors of falls is essential if working with older people.

2.8.1 Risk factors for falls and interventions

Risk factors for falls may be classified as intrinsic (individual specific) or extrinsic (environment / external to the individual) (Boelens et al., 2013; Deandrea et al., 2010; Montero-Odasso, 2019; Phelan & Ritchey, 2018). Intrinsic risk factors for falls include reduced muscle strength, impaired cognition, a decline in visual acuity, gait and balance impairments, and older age (Ambrose et al., 2013; Deandrea et al., 2010; Montero-Odasso, 2019; Phelan & Ritchey, 2018). Extrinsic risk factors for falls include some types of medications such as psychotropics, which could cause postural hypotension and extrapyramidal system side effects (Hill & Wee, 2012; Montero-Odasso, 2019), and fall hazards in the environment such as loose floor mats, and inappropriate footwear (Ambrose et al., 2013; Deandrea et al., 2010; Montero-Odasso, 2019; Phelan & Ritchey, 2018). The risk of falls among older adults rises as the number of risk factors increases and, also due to the interaction of multiple risk factors (Boelens et al., 2013; Montero-Odasso, 2019; Robbins et al., 1989; Stevens & Lee, 2018; Tinetti et al., 1988).

Many intrinsic risk factors, such as balance and gait disorders, and lower body muscle weakness, can be improved with intervention; however other factors such as gender and age cannot (Ambrose et al., 2013). Therefore, timely and appropriate interventions by qualified health professionals, fall prevention programs in the community, or environmental modifications such as sufficient lighting to address these risk factors can reduce the risk of falls (Ganz & Latham, 2020; Stevens & Lee, 2018).

Balance impairment was consistently identified as a risk factor for falls in many reviews of older adults (Ambrose et al., 2013; Boelens et al., 2013; Deandrea et al., 2010; Jehu et al., 2021; Muir et al., 2010b; Zhao et al., 2018) and was responsive to interventions when implemented in the community setting (Sherrington, Fairhall, Wallbank, et al., 2020; Thomas et al., 2019). To date, many studies focused on older adults who have fallen or those with moderate to severe levels of balance dysfunction (Sherrington, Fairhall, Wallbank, et al., 2020; Sherrington et al., 2011). Less attention has focused on older adults with concerns about their balance or those with mild balance dysfunction (Williams et al., 2015; Yang et al., 2011). Older adults with mild balance dysfunction are also at risk of future falls and adverse events (Ek et al., 2017; Muir et al., 2010a). As such, it is important to identify and intervene when older adults' balance dysfunction is still at a mild level of severity because the cost of intervention may be less expensive and/or more effective if identified and intervened earlier

(Beauchamp, 2020; Herman et al., 2002), than intervening when these problems become more advanced. Further description of definitions and classification of mild balance dysfunction, and studies incorporating exercise interventions targeting older adults with mild balance dysfunction, are reported in section 2.10.3.

2.9 Balance and mobility

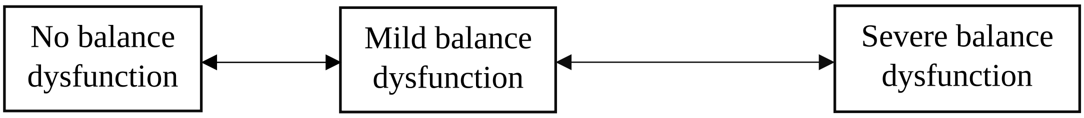
Balance is the ability of the person to maintain the centre of gravity vertically within the base of support (Nashner, 2021; Osoba et al., 2019; Winter, 1995) that includes both static conditions such as sitting, and dynamic conditions when transiting to a new base of support, such as occurs during walking (Winter, 1995). In addition, balance also includes the ability to "resist the destabilising influence of gravity and actively move the centre of gravity" (Nashner, 2021, p. 87).

Balance is a skill required for many independent functional activities, such as mobility (Frank & Patla, 2003) and avoiding falls (Sherrington, Fairhall, Wallbank, et al., 2020). Balance is achieved by the integration and coordination of three systems in the body, the central nervous system, neuromusculoskeletal and sensory systems (Alghwiri & Whitney, 2012; Nnodim & Yung, 2015). Physiological changes associated with ageing in the sensory system and neuromusculoskeletal system, such as reduction in proprioception, reaction time, and strength, can affect balance control and subsequently affect the functional ability of older adults (Daubney & Culham, 1999; Sturnieks et al., 2008; Wingert et al., 2014). These physiological changes, together with pathology affecting the systems (i.e., central nervous system, neuromusculoskeletal and sensory systems), can potentially have adverse effects on older adults' balance and may result in varying severity of balance dysfunction (Nnodim & Yung, 2015; Osoba et al., 2019; Yang et al., 2012).

2.9.1 The balance continuum

Older adults can demonstrate a range of balance performance, from very high levels of balance performance (i.e., no balance dysfunction) to very low levels of balance performance (i.e., severe balance dysfunction) (see Figure 2.1).

Figure 2.1. Continuum of balance



Therefore, it may be necessary to use a different test to assess older adults with low levels of balance performance than to assess older adults with mild balance dysfunction. Similarly, exercise with different levels of difficulty may be most useful and safe for older adults at different parts of the balance continuum.

2.9.2 Domains of balance

Balance consists of several domains, including static and dynamic balance, and dual tasking. Static balance involves “withstanding the destabilising influence of gravity” and “maintaining a stable posture where there is no overt body movement, and it can be assessed using any base of support” (Bernhardt & Hill, 2005, p. 30). For example, one of the tasks included in the Berg Balance Test requires the person to stand for two minutes, which assesses static standing balance.

Dynamic balance involves the movement of the centre of gravity and may include self-initiated movements (i.e., anticipatory balance strategy) or as a response to external perturbations (i.e., reactive balance strategy) (Bernhardt & Hill, 2005; Pollock et al., 2000; Sibley et al., 2015). An anticipatory balance strategy involves voluntary movement or anticipating a predicted perturbation by increasing muscle activity (Pollock et al., 2000; van Dieen & Pijnappels, 2017). For example, in the Berg Balance

Test, one of the tasks requires the individual to reach forward with his/her arm; this is used to assess anticipatory balance.

A reactive balance strategy involves a muscle response or movement due to an unexpected perturbation (Pollock et al., 2000; van Dieen & Pijnappels, 2017) and the strategy used is dependent on the quantity of force generated and the size of the base of support (Alghwiri & Whitney, 2012). These reactive balance strategies consist of the following: ankle strategy (i.e., ankle joint muscles are activated in response to small external perturbations), hip strategy (i.e., hip joint muscles are activated in response to fast and large external perturbations), reaching strategy (i.e., reaching forward to touch or grasp a surface to maintain balance), and stepping strategy (i.e., taking a step to maintain stability if the external perturbation is very large) (Alghwiri & Whitney, 2012). An example of a test assessing reactive balance strategy is the Retropulsion Test, which requires the person to regain their balance after a backward pull applied to the shoulders by the assessor (Visser et al., 2003).

Balance and mobility usually interact together in everyday activities and involve the performance of static or dynamic tasks, which may occur while performing another activity concurrently, such as listening or talking (de Barros et al., 2021). This is known as dual tasking. When a person performs two or more tasks concurrently that demand attention, the performance on one of the tasks may deteriorate (Alexander & Hausdorff, 2008; Doumas & Krampe, 2015). A systematic review revealed that community-dwelling older adults reduced their gait speed significantly while performing another cognitive task (e.g., serial subtractions) (Smith et al., 2016).

In summary, balance performance varies in complexity and consists of multiple domains. Therefore, balance performance cannot be assessed by using a single task or test. In order to obtain a comprehensive picture of the balance ability of the older adult, a series of tests or tasks within a test battery are needed to adequately represent the complex multi-domain nature of balance performance.

2.9.3 Importance of balance tests

Various measurements (e.g., rating scales, assessments, and questionnaires) have been reported in the literature to evaluate balance in older adults (Middleton & Fritz, 2013) and with different conditions, such as stroke (Hugues et al., 2019), vestibular hypofunction (Gill-Body et al., 2000) and osteoarthritis (Picorelli et al., 2018). An accurate balance assessment is important to deliver effective treatment. Assessment of balance is critical for four main reasons:

- To identify the existence and severity of a balance problem to predict the risk of falls (Horak, 1997; Mancini & Horak, 2010; Middleton & Fritz, 2013).
- To identify the nature of balance impairment, which will help inform the selection of targeted exercises to address that balance impairment (Mancini & Horak, 2010).
- To identify progress in performance over time (Horak, 1997; Mancini & Horak, 2010; Middleton & Fritz, 2013). Repeated assessments over time can provide feedback about performance to patients, can assist in decision-making in an intervention plan (e.g., provision of a gait aid if patients are unsteady during walking), and can determine the effectiveness of the intervention, helping to justify whether to continue the intervention and/or to continue the funding of a public health intervention (Hill et al., 2005).
- To evaluate the cost-effectiveness of management by comparing two different intervention programs (Hill et al., 2005).

2.9.4 Considerations for the selection of tests of balance performance

Several factors should be considered when selecting tests for evaluating balance ability or other physical performance:

- Are they appropriate for older adults? Does the assessment identify problems in older adults, including those with similar conditions? (Soubra et al., 2019; VanSwearingen & Brach, 2001).
- Is the test practical and feasible? The length of the test and the physical endurance of the older adult may influence the selection of the test (Soubra et al., 2019; VanSwearingen & Brach, 2001). For instance, the Balance Evaluation Systems Test (BESTest) consists of 36 test items and takes 30 minutes to complete (Horak et al., 2009). This test may not be practical if the older adult fatigues easily.
- The cost of the equipment, space required to conduct the test, duration to set up and undertake the test and portability of the equipment (Soubra et al., 2019; VanSwearingen & Brach, 2001). For instance, the Community Balance and Mobility Scale requires a walkway length of at least eight metres and a set of stairs, which may not be available in some settings (i.e., in a person's home) to enable completion of the full assessment.
- Measurement properties of tests of physical performance, such as balance and mobility, including:
    - Reliability, which is "the extent to which a measurement is consistent and free from error" (Portney & Watkins, 2015a, p. 77). There are three types of reliability: (1) internal consistency, (2) test-retest reliability, and (3) inter-rater reliability (Portney & Watkins, 2015a). Internal consistency is "the extent to which items measure various aspects of the same characteristic and nothing else" (Portney & Watkins, 2015a, p. 89). For example, the internal consistency

of the Community Balance and Mobility Scale was high (Cronbach's alpha = .96) and suggested that the items in the scale measured the targeted domains of balance, mobility and gait (Balasubramanian, 2015). Test-retest reliability provides information about the stability of participants' performance over time (Vilagut, 2014). This means that an individual would obtain the same results if the same test were implemented on different occasions (Vilagut, 2014). Inter-rater reliability refers to the degree when two or more people concur on the scoring of a test (Lange, 2011).

- Validity, which "assures that a test is measuring what it is intended to measure" (Portney & Watkins, 2015a, p. 77). Validity is important to determine how the results of a test are used and for deducing results from the data (Portney & Watkins, 2015a). There are different types of validity, such as content validity, criterion validity and construct validity (Portney & Watkins, 2015b). Content validity is "the extent to which the items on a test are fairly representative of the entire domain the test seeks to measure" (Markus & Smith, 2010, p. 239). For example, if the goal is to measure upper body function, a set of tasks that includes all aspects of upper body function should be included in the test. Criterion validity investigates the degree a test provides results that are comparable with another test that is considered the "gold standard" (Borneman, 2010). For example, if someone is determining the validity of the manual muscle test, the results from the manual muscle test should be compared with results from an assessment using a dynamometer. Construct validity investigates "the extent to which the measurements used, often questionnaires, actually test the hypothesis or theory they are measuring" (Ginty, 2013, p. 29).

- Responsiveness is the test's ability to identify change over a certain time duration (Liang, 2000; Liang et al., 2002; Terwee, 2014). For instance, the test must be able to detect improvement or decline in the component (e.g., balance) being measured after an intervention (assuming the intervention is effective). One characteristic of measurements that influence measurement properties, such as responsiveness, is the presence of ceiling and floor effects. A ceiling effect occurs when the person's score is at the highest point of the test (Portney & Watkins, 2015a) because the test was too easy for the person to perform. For example, if the older adults' scores are clustered at the high end of the test, the ceiling effect may hide the underlying physical performance problem (e.g., balance) and limit the tests' ability to detect changes after intervention. A floor effect occurs when the person's scores are at the lowest point possible in a test (Portney & Watkins, 2015a). The presence of a floor effect does not allow the test to differentiate individuals who did poorly on the test (Lewis-Beck et al., 2004).

2.9.5 Ceiling effects of balance tests

Many balance tests identify "moderate" or "severe" balance and gait problems in older adults (Berg et al., 1992; Faber et al., 2006; Pardasaney et al., 2012). Previous systematic reviews have revealed that several balance tests were unable to identify "early" or mild balance or gait problems in older adults who were higher functioning and living in the community (Bergquist et al., 2019; Langley & Mackintosh, 2007; Power et al., 2014).

For instance, a commonly used, reliable and valid test, the Berg Balance Scale, demonstrated ceiling effects when used in older adults living in the community (Bergquist et al., 2019; Langley & Mackintosh, 2007; Pardasaney et al., 2012; Power et al., 2014) and across different populations such as early stages of Parkinson's disease (Leddy et al., 2011) and stroke (Blum & Korner-Bitensky, 2008). Reasons that may contribute to the ceiling effects of the Berg Balance Scale could include that it focuses on basic functional tasks, such as standing unsupported and does not include dynamic balance tasks that are more challenging such as running (Weber et al., 2018). More challenging tasks such as this are still able to be performed by more well older people (Weber et al., 2018).

Likewise, the Tinetti Performance Oriented Mobility Assessment measures older adults' balance and gait abilities and has also demonstrated ceiling effects in higher functioning older adults (Faber et al., 2006; Pardasaney et al., 2012) and older adults with knee osteoarthritis (Parveen & Noohu, 2017). Another test used to measure older adults' balance, and mobility is the Balance Outcome Measure for Elder Rehabilitation Test (Haines et al., 2007; Kuys et al., 2011). The Balance Outcome Measure for Elder Rehabilitation Test consists of a combination of four tests, which are the Timed Up and Go Test, Step Test, Functional Reach Test and Timed Static Standing Balance Test with Eyes Closed (Haines et al., 2007; Kuys et al., 2011). While some of these tests individually may not suffer from ceiling effects, scores on each test are categorised into five levels for the Balance Outcome Measure for Elder Rehabilitation Test, which may limit its overall ability to discriminate performance. Ceiling effects were also reported for the Balance Outcome Measure for Elder Rehabilitation Test in previous studies of older women with vertebral fractures who were higher functioning in the community (Brown et al., 2019; McArthur et al., 2021). The presence of ceiling effects of these tests may limit or delay the early identification of balance impairments and limit the determination of intervention effectiveness in high functioning older adults (Bergquist et al., 2019; Boulgarides et al., 2003; Pardasaney et al., 2012).

Previous systematic reviews published about mobility in older adults reported that tests such as the Dynamic Gait Index (Power et al., 2014) or the Timed Up and Go test (Schoene et al., 2013) also demonstrated ceiling effects in higher functioning older adults. Similarly, these tests lacked challenging mobility tasks, such as running and hopping.

In summary, the ceiling effects demonstrated in these balance tests prevent the early identification of balance dysfunction in higher functioning older adults. Therefore, for programs targeting higher functioning older adults living in the community, it is important to identify balance tests with limited ceiling effects for this population so that early intervention can be implemented and evaluated to prevent further deterioration of their balance.

The Community Balance and Mobility Scale is one test that may be applicable for higher functioning, community-dwelling older adults. It can evaluate the subtle changes in balance and mobility in higher functioning community-dwelling older adults due to its' lack of ceiling effects (Balasubramanian, 2015; Bergquist et al., 2019; Weber et al., 2018). Unlike the other balance tests described, such as the Berg Balance Scale or the Dynamic Gait Index, the Community Balance and Mobility Scale includes a number of challenging items, such as running and stopping at the finishing line, which allows for greater discrimination of balance and mobility performance in higher functioning older adults.

2.9.6 Community Balance and Mobility Scale (CBMS)

The CBMS was first used to identify balance instability and mobility impairments and assess change after intervention in adults with traumatic brain injury (Howe et al., 2006). Since then, its usage has expanded to include other populations, such as higher functioning older adults living in the community (Balasubramanian, 2015), older adults with stroke (Knorr et al., 2010), and older adults with osteoarthritis (Takacs et al., 2014).

The CBMS measures different components of movement and posture required for function in the community (Howe et al., 2006). The CBMS consists of 13 items that assess skills related to multitasking (i.e., ‘walk and look’) and movement sequencing (i.e., ‘crouch and walk’) and complex motor skills (i.e., ‘run with a controlled stop’). Each item is scored on a scale of zero to five (Howe et al., 2006). A bonus point is given for carrying a weighted laundry basket or a box with the same dimensions while descending stairs (Howe et al., 2006). The CBMS scores range from zero to 96 points, and the higher the CBMS score, the higher the person's function. The CBMS takes approximately 15 (Takacs et al., 2014) to 30 minutes (Howe et al., 2006) to complete.

The CBMS is a valid and reliable measure for older adults living in the community (Balasubramanian, 2015; Weber et al., 2018). The CBMS was initially determined to be valid and reliable among 40 high functioning older adults (mean age = 73.3 years, *SD* = 6.9) recruited from the community (Balasubramanian, 2015). CBMS scores demonstrated a significant correlation with self-report assessments (i.e., Activities Specific Balance Scale) and performance-based assessments such as the Dynamic Gait Index, Berg Balance Scale, the Short Physical Performance Battery, the Timed Up and Go Test, Functional Reach Test, Six Minute Walk Test, and gait speed (Balasubramanian, 2015). High intra-rater reliability ($ICC_{3,k}$ = 0.98, 95% CI [0.93, 0.98]), high inter-rater ($ICC_{2,k}$ = 0.98, 95% CI [0.88, 0.98]) (Balasubramanian, 2015) and high retest reliability (ICC = 0.95, 95% CI [0.70, 0.99]) (Takacs et al., 2014) were reported. High internal consistency (Cronbach’s alpha = .96) suggested that items of the CBMS measure the same construct of balance, gait, and mobility

(Balasubramanian, 2015). In addition, the lack of ceiling effects suggests that the CBMS is sensitive enough to detect mild changes in balance and mobility of active and independent older adults (Balasubramanian, 2015).

Weber et al. (2018) also assessed the validity and reliability of CBMS in 51 adults (mean age = 66.4 years, *SD* = 2.7). The authors found the CBMS to correlate significantly with the three metre tandem walk, Eight Level Balance Scale, the Timed Up and Go test, seven metre habitual gait speed, and the Fullerton Advanced Balance Scale. High intra-rater ($ICC_{3,k}$ = 1.00, 95% CI [0.99, 1.00]) and inter-rater reliability ($ICC_{2,k}$ = 0.97, 95% CI [0.94, 0.98]) were also obtained. Internal consistency was also high (Cronbach's alpha = .88).

A shortened version of the CBMS (s-CBMS) evaluated the balance and mobility of people (aged 60 to 70 years) (Gordt et al., 2020). The s-CBMS consists of four items: 'unilateral stance', 'lateral foot scoot', 'hopping forward', and 'walk, look and carry' (Gordt et al., 2020). The s-CBMS correlated with the CBMS (r (60) = .97). The authors found the s-CBMS to be significantly correlated with the Fullerton Advanced Balance Scale (r (60) = .72, $p < .001$), three metre tandem walk (r (60) = - .67, $p < .001$), fast walking pace (r (60) = .57, $p < .001$), Late-Life Function and Disability Index (r (60) = - .54, $p < .001$), the Timed Up and Go test (r (60) = - .44, $p = .001$) and habitual walking pace (r (60) = .43, $p = .001$). The internal consistency of the s-CBMS was high (Cronbach's alpha = .84) (Gordt et al., 2020). The authors recommended that s-CBMS is a quick screening test that is feasible for large scale studies. Although the s-CBMS reduced the test administration time to 10 minutes (Gordt et al., 2020), the test still required a large space (i.e., eight metres), which limited the practical implementation of the test in older adults' homes with space constraints, which is also a limitation of the full CBMS.

One hundred and fifty five community-dwelling participants (mean age = 66.2 years, *SD* = 2.5) who were able to walk 500 metres without using any walking aid and did not perform 150 minutes of moderate intensity physical activity/week were recruited to determine the responsiveness and sensitivity to change for the CBMS and s-CBMS (Gordt et al., 2021). The study used data from a previous randomised controlled trial (Gordt et al., 2021). The CBMS (standardised response mean = 0.65, 95% CI [0.41, 0.88] and s-CBMS (standardised response mean = 0.55, 95% CI [0.34, 0.72] demonstrated good sensitivity to change for the sample recruited (Gordt et al., 2021). High responsiveness was observed in the lower balance subgroup (classified according to the median separation of the initial scores of the CBMS and s-CBMS) with both tests. Lower responsiveness was reported in the s-CBMS for the better balance subgroup (i.e., obtained ≥ 26 points on the s-CBMS) (Gordt et al., 2021). The findings suggest that CBMS may be more useful for detecting intervention changes across different balance deficits than the s-CBMS.

2.9.7 Rationale for further modification of the CBMS

The lack of ceiling effects in the CBMS suggests that the measure can detect a change in balance and mobility performance of higher functioning older adults (Balasubramanian, 2015). However, its practical use in the community may be limited due to the need for a long walkway (i.e., eight metres in length) and infrastructure (i.e., a flight of stairs with a minimum of eight steps), which may not be readily accessible and available in the community or older people’s homes.

Previous studies have proposed a shortened version of the CBMS (Balasubramanian, 2015; Weber et al., 2018). However, the discussion about modifying the CBMS for use in older people’s homes was lacking, and no other studies could be found exploring this option. One study in this thesis evaluated the measurement properties of a modified

CBMS that was adapted to be used in assessments in older people's homes or settings with limited space (Chapter 5).

2.10 Mild balance dysfunction in older adults

In the literature, the terms 'mild balance dysfunction' and 'mild balance impairments' are often used interchangeably; however, different descriptions and inclusion criteria have been used to identify this population (see Table 2.4 below).

Previous research has successfully used two simple, quick to administer clinical balance tests - the Functional Reach Test and the Step Test for classifying older adults with mild balance dysfunction (Williams et al., 2015) with similar accuracy to a larger suite of clinical and force platform measures used in a previous study (Yang et al., 2011). This study also used different cut-off scores for younger-old (65-74 years) and older-old (75 years and over) participants. Therefore, the inclusion criteria for the pre-post quantitative and qualitative studies in this thesis (Chapters 6 and 7) will follow the description of mild balance dysfunction reported by Williams et al. (2015) (as described in Table 2.4).

2.10.1 Prevalence of mild balance dysfunction

Two hundred and twenty-five adults (aged 65 years and over) who expressed concerns about their balance or mobility and walked independently with or without a walking aid (i.e., able to walk outdoors) were recruited to identify older adults with mild balance dysfunction (Yang et al., 2011) (described in Table 2.4). The authors identified that almost three-quarters of the participants had a measurable mild balance dysfunction (Yang et al., 2011). This finding suggests that many older adults, especially those concerned about their balance, live in the community with mild balance dysfunction.

Table 2.4. Description and inclusion criteria of mild balance dysfunction and mild balance impairment in different studies

Authors	Terminology	Description and inclusion criteria
Nnodim et al. (2006)	Mild balance impairment	Older adults who had difficulty sustaining single leg stance for 25 seconds or demonstrated one error or more during a 10-step tandem walk
Hernandez et al. (2008)	Mild balance impairment	Older adults who had difficulty sustaining single leg stance for 25 seconds or demonstrated one error or more during tandem walk
Yang et al. (2012)	Mild balance dysfunction	Older adults who expressed concerns about their balance, ambulate independently with no more than a walking stick, experienced no more than one fall in the past 12 months, scored < 26 cm on the Functional Reach Test, < 13 steps/ 15 seconds during the Step Test, took > 17.9 seconds to complete the Five Times Sit to Stand Test and obtained three or more abnormal scores on the NeuroCom Balance Master
Williams et al. (2015)	Mild balance dysfunction, mild balance impairment	Older adults who expressed concerns about near falls, confidence or balance, ambulate independently with no more than a walking stick, experienced no more than one fall in the past 12 months, and performance on either (or both) the Functional Reach Test or Step Test scores were below the cut-off scores for their age (65-75 years, <29 cm and <17 steps / 15 seconds respectively; and >75 years, <27 cm and <15 steps / 15 seconds respectively)
Sinaei et al. (2016)	Mild balance impairments	Older adults who were able to maintain static standing balance for five minutes with eyes open and scored between 45 to 52 when assessed using the Berg Balance Scale
Rezaei et al. (2021)	Mild balance impairments	Older adults who were ambulating independently without using a walking aid and scored between 25 to 35 when assessed using the Fullerton Advanced Balance Scale

2.10.2 Clinical presentation of older adults with mild balance dysfunction

Balance-related concerns such as “my balance is not as good as before” and “not feeling steady” are common complaints among older adults (Yang et al., 2011). Older adults’ self-reported impaired balance was associated with a history of falls and future falls risk (Muir et al., 2010a). Older adults often talk about feeling unsteady, but they often do not consult a health professional about their concerns, as they often attribute their unsteadiness to ‘getting old’ (Williams et al., 2015; Yang et al., 2011). They may limit their activities due to a fear of falling, which can further affect their functional ability over time (Auais et al., 2017; Deshpande et al., 2008). Therefore, identifying mild balance dysfunction by conducting earlier assessments and delivering interventions has the potential to reduce secondary problems, such as reduced activity levels and decreased confidence (Gouveia et al., 2016; Hill & Schwarz, 2004) and may prevent functional decline (Grimmer et al., 2016).

A cross sectional study identified the following risk factors associated with mild balance impairments: use of a walking stick (Odds ratio (OR) = 4.80, 95% CI [1.40, 16.47]), self-reported balance concerns during walking (OR = 2.21, 95% CI [1.02, 4.79]), lower self-reported physical activity levels (OR = 0.80, 95% CI [0.65, 0.98]) and slower gait speed (OR = 0.82, 95% CI [0.69, 0.96]) (Yang et al., 2011). These findings suggest that older adults with mild balance dysfunction may be almost five times more likely to use a walking stick, are twice as likely to have self-reported balance concerns during walking, reduced levels of physical activity and demonstrate slower gait speeds. Slower gait speed is associated with increased disability, poorer health status, higher medical costs, and longer hospital stays (Fritz & Lusardi, 2009; Middleton et al., 2015). Therefore, gait speed may be used to monitor and assess an older person's functional status and overall health.

2.10.3 Interventions for older adults with mild balance dysfunction (using any classification)

A small number of studies have demonstrated that older adults with mild balance dysfunction can improve their physical performance with appropriate intervention. Forty eight older adults with mild balance impairments (described in Table 2.4) were randomly allocated into two groups, that is, the balance training group (n = 24) and the neurofeedback training group (n = 24) in a RCT (Rezaei et al., 2021). The balance training group received 12 sessions of 45 minutes of balance training, and the neurofeedback training group received 12 sessions of 30 minutes of neurofeedback training across four weeks (Rezaei et al., 2021). Both groups demonstrated significant improvements in balance and falls risk within groups and a significant difference between groups, with better balance and lower fall risk in the balance training group compared to the neurofeedback training group (Rezaei et al., 2021). It was not reported whether the training sessions were conducted in a group or as one-to-one sessions.

In another RCT, 24 older adults with mild balance impairment (described in Table -2.4) from the community were randomly assigned to single task (n = 12) and dual task balance training (n = 12) (Sinaei et al., 2016). Both groups (i.e., groups of four persons in each session) received 45 minutes of training, three times per week for a month (Sinaei et al., 2016). Both groups improved their balance performance significantly after four weeks (Sinaei et al., 2016). However, no significant differences in change in balance performance were demonstrated between the groups.

In a personalised home-based balance, strength and walking training program, based in part on the Otago Exercise program, but with additional exercises from the Vestibular Exercise Kit and Visual Health Information Balance, balance and strength in older adults with mild balance dysfunction were improved (described in Table 2.4) (Yang et al., 2012). Participants of the program were encouraged to perform the exercises five times per week for six months. The physiotherapist visited the participants intermittently to modify or monitor the home exercise program as required. Post-intervention, the participants improved significantly in their physical performance, such as dynamic standing balance (Step Test and Functional Reach test), strength (hip abductor strength) and walking ability (gait step width) compared to the control group (Yang et al., 2012). In addition, the authors also found that 23.7% of participants improved their balance performance to be within the normal range after the home-based program (i.e., participants were no longer meeting the classification of mild balance dysfunction) (Yang et al., 2012).

In a home-based pre-post intervention translation study conducted through community health centres, 58 participants with mild balance dysfunction (described in Table 2.4) were encouraged to perform five days per week of exercises selected from the Otago Exercise Program and Heath Promotion Resources Balance and Vestibular Exercise for a duration of six months (Williams et al., 2015). In addition, the physiotherapist visited the participants intermittently to oversee or modify their home exercise program as required. After the intervention, significant improvements were found in lower body muscle strength (timed sit to stand), dynamic standing balance (Step Test, Functional Reach test, Four Square Step Test), and walking ability (gait speed) (Williams et al., 2015). In addition, 26.0% of the participants improved their balance performance, which returned to the normal range (i.e. participants were no longer meeting the classification of mild balance dysfunction) (Williams et al., 2015).

Nine participants from the previous study (Williams et al., 2015) were interviewed to understand their experiences participating in the home-based exercise program (Meyer et al., 2016). Health benefits, commitment to the program, and involvement of a health professional were important for continued participation (Meyer et al., 2016). The participants recognised that exercising alone at home was convenient and practical (Meyer et al., 2016). The results suggest that older adults with mild balance dysfunction find home-based exercise programs acceptable.

In another study, older adults with mild balance impairments (classified as described in Table 2.4) were assigned to Tai Chi training (n = 107) and balance and stepping training (n = 106) (Nnodim et al., 2006). Both groups underwent one-hour sessions, thrice-weekly for 10 weeks (Nnodim et al., 2006). Both groups improved in balance, stepping and mobility performance, but the balance and training group demonstrated greater improvements in balance (Nnodim et al., 2006).

Previous studies have investigated older adults with mild balance dysfunction undergoing various types of training such as balance, strength, and walking training at home (Williams et al., 2015; Yang et al., 2012), single and dual task balance training (Sinaei et al., 2016), balance and neurofeedback training (Rezaei et al., 2021), and Tai Chi, stepping and balance training (Nnodim et al., 2006). Results from these studies have shown a range of positive outcomes, as described in section 2.10.3. However, there is limited research investigating whether multi-modal training using other approaches, such as exercising outdoors, and using outdoor exercise equipment conducted in a group, can improve physical performance (including balance) for older adults with mild balance dysfunction.

2.11 Specificity of training

Specificity of training states that gains in performance will occur if the individual practices activities similar to the activity they want to improve on (Hawley, 2008; Liu et al., 2014; Reilly et al., 2009). For instance, if the desired outcome is to improve balance, balance activity must be included and be a focus in the training program. Therefore, to achieve training adaptations, a program must overload the systems involved in the performance of a particular activity (Reilly et al., 2009).

For example, when the intervention programs included resistance training, improvements in muscle strength were reported (Guizelini et al., 2018; Solberg et al., 2013). Similarly, when intervention programs included balance training, the balance of the older adults improved (Duque et al., 2013; Gusi et al., 2012; UzunkulaoĞlu et al., 2019). When functional tasks were included in a training program, activities of daily living improved (Dobek et al., 2007; Solberg et al., 2013). Including sit to stand as an exercise in an intervention program demonstrated improvements in sit to stand performance (Alexander et al., 2001; Dobek et al., 2007; Duarte et al., 2020; Helbostad et al., 2004). Improvements will occur if an older person practices an activity they want to improve with sufficient dosage and intensity. Therefore, balance exercises should be included in the training program to improve mild balance dysfunction.

2.12 Multi-modal exercise

Exercise is one of the most effective interventions to improve an older person's health and well-being. Multi-modal exercise programs usually include a combination of balance and/or strength and/or endurance and/or function, and/or flexibility training (Bouaziz et al., 2016; Gianoudis et al., 2014; Gillespie et al., 2012; Rubenstein et al., 2000; Sherrington et al., 2019; Shigematsu et al., 2008).

Multi-modal exercise programs can be delivered in a group at a community centre or be performed at home or at fitness facilities. A number of group- and home-based multi-modal exercise programs have been found to prevent falls (Cho et al., 2018;

Hewitt et al., 2018; Levinger et al., 2022; Liu-Ambrose et al., 2019), improve balance (Cho et al., 2018; Gianoudis et al., 2014; Shigematsu et al., 2008; Trombetti et al., 2011; Yamada et al., 2013), mobility (Rubenstein et al., 2000; Sherrington et al., 2014; Trombetti et al., 2011; Yamada et al., 2013) and lower body muscle strength (Gianoudis et al., 2014; Uusi-Rasi et al., 2017). Multi-modal exercises such as yoga can also improve balance and mobility (Bucht & Donath, 2019; Groessl et al., 2018; Tew et al., 2020), and Tai Chi can improve balance and lower body muscle strength (Wang et al., 2021) and reduce risk of falls in older adults (Mortazavi et al., 2018). Some of the established programs in the literature, such as Lifestyle-Integrated Functional Exercise (which consists of balance and strength exercises integrated into daily life) and the Otago Exercise Program (which consists of strength, balance, and walking exercises) improved balance, mobility, lower body muscle strength and incidence of falls (Clemson et al., 2012; Dadgari et al., 2016).

These findings suggest that group- and home-based exercise programs, yoga, Tai Chi, and established programs (such as Otago Exercise Program and Lifestyle-Integrated Functional Exercise) that include multi-modal training are beneficial to physical performance and reduce the risk of falls among older adults. To reduce the risk of falls, multi-modal exercises should include balance exercises. However, these multi-modal exercise programs vary in the mode of delivery (unsupervised or supervised, home- or group-based) and prescription (duration, type, frequency, and intensity) of exercise.

From the findings described, home- or group-based multi-modal exercise plays a critical role and is effective in improving physical performance and reducing the risk of falls in older adults. However, to reduce the risk of falls, multi-modal exercises should include balance exercises.

2.13 Outdoor exercise parks

Parks are located in most neighbourhoods and offer opportunities for being physically active outdoors in the community (Chow, 2013; Oliveros et al., 2021). Performing physical activity outdoors in open green spaces may positively influence older adults' health (Dadvand et al., 2016; Levinger, Cerin, et al., 2021) by improving their mental well-being (Gladwell et al., 2013). Outdoor exercise equipment installed strategically in parks (known as outdoor exercise parks in this thesis) is an example of a public health approach that encourages community participation in physical activity (Ng, Hill, Levinger, et al., 2021). Most outdoor exercise parks installed are designed for people aged 13 years and above (Cohen et al., 2012; Ng, Hill, Levinger, et al., 2021) (see Figure 2.2). Outdoor exercise parks can be installed at different places along a track or combined together in a public park or outdoor space (City of Sydney, 2020).

Figure 2.2. Outdoor exercise park

Note. Photograph courtesy from Ng (2022)

There are, however, outdoor exercise parks built specifically for older adults, known as Seniors Exercise Parks, and they include balance exercise equipment, unlike most outdoor exercise parks and also include all of the equipment in one small space (Levinger et al., 2020; Levinger et al., 2018; Sales et al., 2017).

Older adults use outdoor exercise parks mainly to improve their health (Chow, 2013) and fitness (Stride et al., 2017). When surveyed, older adults perceived that the provision of shade, increased number and variety of equipment pieces, and provision of classes would increase outdoor exercise park use (Stride et al., 2017). Although outdoor exercise parks are often readily accessible, a survey found that only one-quarter of older adults who visited the park used the outdoor exercise park equipment (Stride et al., 2017). Supervised exercise classes conducted twice weekly for four weeks on the safe and effective use of outdoor exercise park equipment could attract existing and new users, improve their confidence about equipment use, and encourage future use (Scott et al., 2014). These studies support the notion that older adults are open to the idea of using outdoor exercise parks for exercise and that instructional classes can increase their physical activity and use of outdoor exercise equipment, and potentially improve their health.

Two systematic reviews (Jansson et al., 2019; Lee et al., 2018) have been conducted about outdoor exercise parks (Ng, Hill, Levinger, et al., 2021). Lee et al. (2018) found that the opportunity to form social connections and improve health were the main reasons for outdoor exercise park use. Jansson et al. (2019) reported that using outdoor exercise parks could improve physical activity and physical fitness. These systematic reviews provided information about the effects of outdoor exercise parks on health outcomes, and usage across all ages and did not focus on older adults (Ng, Hill, Levinger, et al., 2021). In addition, the use and effects of exercise parks on physical function, physical activity, psychosocial and quality of life outcomes reporting specifically about older adults were limited (Ng, Hill, Levinger, et al., 2021).

2.13.1 Research on outdoor exercise park interventions

Several studies have been conducted on the effects of outdoor exercise park interventions on older adults. A summary of the terminologies, number and name of exercise stations and type of training is presented in Table 2.5.

In a RCT by Leiros-Rodríguez and García-Soidan (2014), women aged 65 years and above, who sensed a decline in balance and walked independently without a walking aid in the community were recruited. The participants underwent twice-weekly balance training, for 50 minutes each session, for six weeks using outdoor exercise parks. The use of the outdoor exercise equipment was integrated for balance training during the supervised intervention, although it did not involve specific exercise equipment / stations specifically designed to challenge balance – instead, balance challenging exercise was conducted while using the exercise equipment challenging other physical performance domains. For example, the participant's base of support was adjusted (e.g., standing on her heels) for balance training while using the shoulder wheel to improve shoulder flexibility. It is likely balance training would not occur if the intervention were unsupervised because the outdoor exercise equipment is built to target strength, aerobic and flexibility training and does not include specific balance exercise equipment. Significant improvements were found in balance, mobility, and quality of life at the end of six weeks in participants who underwent supervised outdoor exercise park training compared to the control group who continued with their daily routine (Leiros-Rodríguez & García-Soidan, 2014).

Table 2.5. Number and name of exercise stations and type of training using outdoor exercise parks

Study	Terminology	Number of exercise stations	Name of exercise stations	Type of training for each exercise station
Leiros-Rodriguez and Garcia Soidan (2014)	Equipment in a public park	12	The names of the exercise stations were not included.	Static and dynamic balance training
Kim et al. (2018)	Outdoor exercise machines	5	Pull weight, chair pull, leg extension, sky walk, cross country	Resistance training: Pull weight, chair pull and leg extension: Aerobic training: Sky walk and cross country
Liu et al (2020)	Outdoor fitness equipment	3	Air walker, arm stretcher, leg press	Aerobic training: Air walker Flexibility training: Arm stretcher Resistance training: Leg press
Kowalska and Czesak (2021)	Outdoor gym	6	Rider, surfer, orbiter, overhead hoist, jogger, and foot press	Not reported
Chow et al. (2021)	Outdoor fitness equipment	6	Air walker, ski machine, rowing machine, bonny rider, arm stretch, shoulder wheel	Aerobic training: Air walker, ski machine Flexibility training: Arm stretch, shoulder wheel Resistance training: Rowing machine, bonny rider Balance training: Waist twister
Sales et al. (2017) and *Sales et al. (2018)	Seniors Exercise Park	16	Push-ups, modified pull-ups, balance stool, sit to stand, ramp + net + climb through, balance beam, step ups, taps on platform, gangway, calf raises + finger steps, rounded snake pipe, hip extension, screw or turners, hip abduction, walking on the ropes, sharp snake pipe, stairs	Strength training: Push-ups, modified pull-ups, step ups, calf raises + finger steps, hip extension, hip abduction Balance training: Balance stool, gangway, ramp + net + climb through, balance beam Coordination training: Taps on platform, rounded snake pipe, sharp snake pipe Functional training: Screw or turners, stairs, sit to stand
Levinger et al. (2020), *Levinger et al. (2021), and #Levinger et al. (2022)	Seniors Exercise Park	18	Push-ups, pull-ups, balance stool, sit to stand, ramp + net + climb through, balance beam, step ups, taps on platform, gangway, calf raises + finger steps, rounded snake pipe, hip extension, hip abduction, walking on the ropes, snake pipe (big wave), stairs, handroll, shoulder arches	Strength training: Push-ups, modified pull-ups, step ups, calf raises + finger steps, hip extension, hip abduction Balance training: Balance stool, gangway, ramp + net + climb through, balance beam, walking on the ropes Coordination training: Taps on platform, snake pipe (small wave), snake pipe (big wave), handroll, shoulder arches Functional training: Stairs, sit to stand

Note. *Qualitative study conducted in conjunction with the quantitative study.

#This study (Levinger et al. 2022) reported falls outcomes which was not reported in the first published quantitative study (Levinger et al. 2020).

In a RCT by Kim et al. (2018), people aged over 65 years, with no illness over the previous six months and who were not exercising regularly in the three months prior were recruited. The participants underwent thrice-weekly sessions for six weeks. The resistance training group underwent 70 minutes of resistance exercise using an outdoor exercise park, while the combined training group underwent 90 minutes of aerobic and resistance exercise using the outdoor exercise park (Kim et al., 2018). Both intervention groups demonstrated significant improvements in upper body muscle strength and endurance (Kim et al., 2018). Only the combined training group demonstrated significant improvements in static standing balance (Kim et al., 2018). However, it must be noted that dynamic standing balance was not measured in this study.

Liu et al. (2020) conducted a RCT with people aged 65 years and older, who ambulated independently in the community and lived in the same village. They underwent incremental duration aerobic exercise (e.g., three sets of 10 minutes during weeks one to four, followed by three sets of 12 minutes during weeks five to eight, then three sets of 14 minutes during weeks nine to 12), incremental sets of muscle strength exercise (e.g., two sets during weeks one to four, three sets during weeks five to eight, and four sets during weeks nine to 12, with each set, consisting of 12 repetitions), and incremental repetitions of flexibility exercises (e.g., six repetitions during weeks one to four, eight repetitions during weeks five to eight, and 12 repetitions during weeks nine to 12 with each repetition held for 30 seconds) using outdoor exercise parks three times per week for 12 weeks. The control group continued with their usual activities. Following the intervention, no significant improvements were demonstrated (Liu et al., 2020). The authors attributed this to several reasons: (i) the participants were higher functioning (i.e., their performances were above the mean values in some components of the Seniors Fitness Test, such as the Two Minute Step Test, Back Scratch Test, Sit to Stand Test); (ii) inadequate exercise duration; (iii) there was no adjustable resistance on the exercise equipment, except the participant's body weight, which may not have been sufficient to improve lower body muscle strength, although the number of sets performed by the participants were increased periodically throughout the intervention period; and (iv) the intensity for aerobic training was not vigorous enough.

In a pre-post intervention study by Kowalska and Czesak (2021), people aged 60 to 74 years old, with no comorbidities, and who participated in gymnastics classes at a club in Poland were recruited. The participants participated in thrice-weekly exercise sessions for 45 minutes each session for four weeks using outdoor exercise parks (Kowalska & Czesak, 2021). At the end of their training, significant improvements were shown in upper and lower body muscle strength, flexibility, agility, dynamic balance and endurance (Kowalska & Czesak, 2021).

Chow et al. (2021) recruited healthy community-dwelling people aged 60 years or above who participated in a two-phase outdoor exercise park training program supervised by a certified fitness trainer. Twenty participants underwent aerobic exercises five times a week for 40 minutes for 12 weeks using the ski machine and air walker at a rate of 60 steps per minute during phase one training (Chow et al., 2021). The same 20 participants and an additional nine participants underwent muscle strength, balance, and flexibility training twice-weekly for 30 minutes for 12 weeks during phase two training using the outdoor exercise park (Chow et al., 2021). The outdoor exercise park equipment was not built for balance training. Balance training was integrated during the intervention by adjusting the participants' base of support (e.g., participant stood on one leg) while they were using the waist twister, which is aimed at improving flexibility of the waist. Significant improvements were observed in endurance following phase one training, handgrip and lower body muscle strength and static standing balance following phase two training (Chow et al., 2021). In summary, the results of the studies reported above suggest that interventions using outdoor exercise parks can improve physical performance and quality of life in older adults.

2.13.1.1 Seniors Exercise Parks

Seniors Exercise Parks (supplied by Lark Industries are specialised outdoor exercise equipment built specifically for older adults (Levinger et al., 2020) (see Figure 2.3).

Figure 2.3. Seniors Exercise Park

Note. Photograph courtesy from Ng (2021)

Seniors Exercise Parks offer multi-modal activities (e.g., balance, coordination, functional movement, strength, and flexibility) in a single location (Levinger et al., 2018). In addition, a unique feature of the Seniors Exercise Park is that it includes equipment built for balance training (e.g., balance beam), whereas most outdoor exercise park equipment does not, unless the exercises are adapted to include balance training during supervised interventions, while using the equipment designed for a different purpose (e.g., performing a shoulder wheel exercise built to improve shoulder flexibility while standing on one leg).

Sales et al. (2017) recruited older adults in a RCT in Australia who were concerned about falling or who had experienced one or more falls in the past year and were independently ambulating with or without a walking stick outdoors. The intervention included twice-weekly exercise sessions for 60-90 minutes for 18 weeks using the Seniors Exercise Park. All sessions were supervised by an accredited exercise physiologist. At the end of the training, the primary outcome measure (i.e., Balance Outcome Measure for Elderly Rehabilitation) did not demonstrate any significant improvements. Lack of improvements in the Balance Outcome Measure for Elderly Rehabilitation test may be due to the ceiling effects of this tool in a higher functioning group of older adults. However, improvements were shown on lower body muscle strength, endurance, and single leg stance.

In a qualitative study by Sales et al. (2018) conducted in conjunction with the Seniors Exercise Park RCT described above (Sales et al., 2017), participants perceived they had improved confidence, physical performance (e.g., strength and balance), gait, and activities of daily living (e.g., climbing stairs). Participants reported social interaction, physical health improvement and supervision as valuable benefits of the intervention after the RCT (Sales et al., 2018). Pairing up the participants during training sessions may have encouraged social interaction because the participants could chat with each other while exercising (Sales et al., 2018).

In a pre-post intervention study, people aged 60 years and over, with concerns about falling or who had one or more falls in the past year, who were walking independently outdoors with or without a walking stick and had no cognitive impairment participated in an 80 minute, twice-weekly supervised structured Seniors Exercise Park intervention for three months in Australia (Levinger et al., 2020). After the three months of supervised training, the participants continued their Seniors Exercise Park training independently without supervision or could attend non-structured supervised sessions for the next six months (Levinger et al., 2020). Physical activity levels, physical function measures, well-being, loneliness, quality of life, and fear of falls improved significantly at three months (Levinger et al., 2020). The participants' physical activity levels, physical function measures, falls risk, fear of falls and depression scores also improved significantly at nine months compared to baseline (Levinger et al., 2020). These results suggest that improvements were maintained if participants continued training independently when the supervised sessions stopped.

Participants who underwent the Seniors Exercise Park intervention in the previous study (Levinger et al., 2020) were monitored for falls for 12 months from the start of the intervention (Levinger et al., 2022). Falls were recorded by the participants using calendars which were returned to the researchers at the end of every month (Levinger et al., 2022). Falls incidence was reduced by 31% ($p < .01$), and the percentage of older adults who fell decreased by 20.4% ($p = .03$) (Levinger et al., 2022). The results suggest Seniors Exercise Parks have the potential to reduce falls in older adults. However, the authors acknowledged that the inclusion of participants in their study was based on retrospective recall of falls in the preceding 12 months, and the incidence of actual falls may be under-reported by the participants.

In a qualitative study by Levinger, Dunn, et al. (2021) conducted in tandem with the pre-post intervention study reported above (Levinger et al., 2020), the authors explored the participants' perceptions about factors influencing their participation during the three month supervised structured program and during the additional six months of independent training at the Seniors Exercise Park or supervised non-structured sessions. The enablers supporting participation were the availability of supervision, health benefits and the social benefits (Levinger, Dunn, et al., 2021). Participants cited weather, health/medical problems, and other commitments as the main barriers to Seniors Exercise Park participation.

In summary, previous studies (Chow et al., 2021; Kim et al., 2018; Kowalska & Czesak, 2021; Leiros-Rodríguez & García-Soidan, 2014; Levinger et al., 2020; Sales et al., 2017) revealed that outdoor exercise parks could improve physical performance and quality of life in older adults, and in some instances, may reduce falls incidence and the percentage of older adults who fell. Only one study found no significant effects on physical performance following an outdoor exercise park intervention (Liu et al., 2020). The number and type of exercise stations, frequency, duration, and length of intervention differed across studies. To enable effective comparison across studies, greater consistency in the number and type of exercise stations, and intervention parameters (e.g., duration) for future research would be valuable to determine the effectiveness of outdoor exercise parks.

Criteria for inclusion of participants in the previous studies reported above included participants who sensed a decline in balance (Leiros-Rodríguez & García-Soidan, 2014), independent participants who were physically inactive over the preceding three months (Kim et al., 2018), generally well participants (Chow et al., 2021; Kowalska & Czesak, 2021; Liu et al., 2020), and participants with concerns about falling or who had one or more falls in the past year, and were walking independently outdoors with no more than a walking stick (Levinger, Dunn, et al., 2021; Levinger et al., 2020; Sales et al., 2018; Sales et al., 2017). Participants were not screened or selected for the presence of mild balance dysfunction using standardised tests such as those recommended by Williams et al. (2015) (i.e., scored below normative scores for their age in the Step Tests and/or Functional Reach Test) (See Table 2.4) in any of these studies.

2.13.2 Adverse events in outdoor exercise parks

In previous research conducted with outdoor exercise parks (Chow et al., 2021; Kim et al., 2018; Kowalska & Czesak, 2021; Leiros-Rodríguez & García-Soidan, 2014; Liu et al., 2020), adverse events were only reported in two studies (Levinger et al., 2020; Sales et al., 2017). Two falls (Sales et al., 2017) and one fall (Levinger et al., 2020) were reported during the Seniors Exercise Park use; however no injuries were reported from these incidents (Levinger et al., 2020; Sales et al., 2017). The safety features of a Seniors Exercise Park can be enhanced by adding non-slip tape to some exercise stations and installing soft fall flooring to prevent injury around the equipment (Levinger et al., 2019; Levinger et al., 2018). Even though participants exercised with a perceived exercise exertion between four (somewhat hard) to seven (very hard) on the 10-point Borg Rating of Perceived Exertion Scale during the intervention (Levinger et al., 2019; Sales et al., 2015), there was no reported delayed fatigue or onset muscle soreness during or after either intervention (Levinger et al., 2020; Sales et al., 2017). The findings suggest that Seniors Exercise Parks are a safe physical activity option for older adults.

2.13.3 Adherence to outdoor exercise parks training

The adherence rates to supervised outdoor exercise park training (Chow et al., 2021; Kim et al., 2018; Kowalska & Czesak, 2021; Leiros-Rodríguez & García-Soidan, 2014; Liu et al., 2020) were not reported, except for two studies (Levinger et al., 2020; Sales et al., 2017). High adherence rates, ranging from 84.2% to 87%, were reported during supervised Seniors Exercise Park training sessions (Levinger et al., 2020; Sales et al., 2017).

Some older adults were more likely to continue their exercise participation if there was encouragement and the friendship of others, the opportunity to interact socially, and if the program was supervised (Bethancourt et al., 2014; Burton, Farrier, et al., 2017; Spiteri et al., 2019). Therefore, delivering the Seniors Exercise Park interventions in a group initially, and then removing the supervision gradually, may be an important catalyst for older adults to continue their physical activity engagement beyond the supervised program.

2.13.4 Rationale for Seniors Exercise Park intervention

To add to the existing knowledge about the effects of outdoor exercise parks, quantitative and qualitative studies (Chapters 6 and 7) were conducted as part of this PhD series of studies on Seniors Exercise Parks, as these purpose-built outdoor exercise parks include multi-modal training (including balance exercise) and could target physiological components associated with ageing (Levinger et al., 2018). Two published studies (Levinger et al., 2020; Sales et al., 2017) demonstrated that exercise conducted using a Seniors Exercise Park in a group supervised by a health professional was feasible and safe for older adults. However, two main factors in the implementation methods of these studies may limit broader application.

Firstly, all the programs required continuous twice-weekly intensive supervision by a health professional for a period ranging from 12 weeks (Levinger et al., 2020) to 18 weeks (Sales et al., 2017). The constant and intensive supervision placed rigid time demands on participants (being at sessions on fixed times and fixed days) and those delivering the programs. Older adults who are generally active and independent may not require ongoing continuous supervision. In addition, participants could choose to attend supervised and unstructured Seniors Exercise Park training or independent practice for another 24 weeks following 12 weeks of intervention (Levinger et al., 2020). No research studies have explored the gradual reduction of supervision progressing to independent practice approach, which may be more acceptable for participants, and may be more beneficial in terms of longer-term sustainability.

Secondly, participants in the previous studies (Levinger et al., 2020; Sales et al., 2017) were predominantly in the higher functioning and well category. The Balance Outcome Measure for Elder Rehabilitation test (the primary outcome measure) demonstrated ceiling effects with this sample (Sales et al., 2017). The Step Test results of combined lower extremities at baseline were 20.4 steps (*SD* = 6.7) (Levinger et al., 2020), which was higher than the average steps (mean steps = 17.5 steps, *SD* = 3.0) reported for well older adults (Hill, Bernhardt, et al., 1996). This suggests that participants recruited in these previous studies were high functioning, and these samples are less likely to have included older adults with balance dysfunction at the commencement of the Seniors Exercise Park intervention.

To date, no research has explored whether exercising in a group using Seniors Exercise Park equipment can improve the physical performance, psychosocial and quality of life outcomes of older adults with mild balance dysfunction. Also, the feasibility and safety for older adults with mild dysfunction to use the Senior Exercise Park equipment independently (i.e., without supervision) has not been investigated. A study of this nature will increase the confidence that this approach may also be safe and effective for older people with a measurable decline in balance performance. In addition, the experiences and factors influencing participation of older adults with mild balance dysfunction during a Seniors Exercise Park training program and independent self-practice are unexplored.

2.14 Coronavirus (COVID-19)

Coronavirus is “a large family of viruses that are phenotypically and genotypically diverse” (Hammami et al., 2020, p. 26) and is highly infectious through human interaction (Parnell et al., 2020). The outbreak of COVID-19 began in Wuhan, China (Zhu et al., 2020) and has since spread across the world. COVID-19 was declared as a worldwide pandemic in March 2020 (World Health Organisation, 2020a).

Sporting and cultural events, travel, and social gatherings were banned, and universities, schools, and leisure and fitness facilities were closed to minimise the spread of COVID-19 (Cowling & Aiello, 2020; Parnell et al., 2020). People were advised to stay at home, and returning travellers were required to self-isolate for up to two weeks or more to prevent the virus from spreading (Han et al., 2020; Parnell et al., 2020). This PhD thesis was completed during the height of the COVID-19 pandemic.

2.14.1 Changes in behaviour and physical activity of older adults during the pandemic

Many countries throughout the world-imposed lockdowns at different times on their citizens due to COVID-19. Lockdowns consisted of strict restrictions enforced by authorities on entry to public areas, travel, and social interaction (Collins Dictionary, 2020). The closure of fitness and sports facilities reduced opportunities for older adults to be physically active in organised group activities, such as line dancing or lawn bowls.

Before the COVID-19 pandemic, physical inactivity was already a public health challenge facing older adults globally. However, since the pandemic began, many older adults have become concerned about contracting the virus. Therefore, to reduce their risk of contracting COVID-19, they have been practicing physical distancing or self-isolating (Gonçalves et al., 2021; Wu, 2020). Older adults following official advice were staying at home and self-isolating, which could have negatively affected their physical activity behaviours. They may have adjusted their lifestyles, such as modifying or stopping their exercise or how they like to be physically active or reduced their social activities, such as volunteering outside their home during these periods of lockdown.

2.14.2 Effects of COVID-19 on physical activity and health

Older adults appear to have been less physically active or spent less time engaging in physical activity during the COVID-19 pandemic. Almost half of the older adults (42.3%) surveyed in the United Kingdom were less physically active compared to before the lockdown period (Brown et al., 2021). A study in the Netherlands also reported a similar reduction in physical activity participation during the pandemic (Visser et al., 2020). A high percentage (i.e., 63.4%) of older adults in Australia did not engage in adequate physical activity during the pandemic (Kunstler et al., 2020). In the United States of America and Canada, 37.6% of older adults reported performing less physical activity, while practicing physical distancing (Callow et al., 2020). Older adults in Japan spent 65 fewer minutes per week engaging in physical activity during the pandemic compared to pre-covid times (Yamada et al., 2020). These findings suggest that older adults adjusted their physical activity routines and levels during the COVID-19 pandemic and that lockdowns may have had an adverse effect on how physically active they could be.

A previous qualitative study revealed that older adults were unaware and not keen to use online videos for being physically active, although they understood the importance of continuing their physical activity at home during the COVID-19 pandemic (Goethals et al., 2020). This group of older adults also reduced their attendance at group-based physical activity programs during the pandemic (Goethals et al., 2020).

Restriction of movement, interruption to routines, and separation from friends and family meant that habits and networks to sustain physical activity levels altered suddenly (Cunningham & O' Sullivan, 2020). Reduced physical and social contact may have caused frustration, a sense of isolation, anxiety, and boredom (Brooke & Jackson, 2020; Robb et al., 2020). In addition, prolonged time at home may have increased sedentary behaviour, such as increased duration spent reclining, lying down, and sitting (e.g., reading, watching television, playing games on mobile devices). These behaviours can lead to increased risks of chronic medical conditions (e.g., cardiovascular disease, diabetes, cancer) (Lippi et al., 2020; Wahid et al., 2016), recurrent falls, reduced cognitive functioning and poor quality of life (Cunningham et al., 2020).

Reduction of physical activity can also lead to deterioration in functional performance and metabolic profiles in older adults. A decline in mental health, physical function, and deterioration in lipid, blood pressure, and glucose levels in older adults can occur after three months of detraining (Esain et al., 2019; Leitão et al., 2019). Reduced muscle mass and strength can lead to functional decline in older adults following periods of inactivity (Bowden et al., 2019; da Rocha et al., 2021). In addition, an increase in sedentary behaviour has been associated with poorer mental and physical health during the pandemic (Cheval et al., 2021; Hoffman et al., 2022; Salman et al., 2021). Increased inactivity and sedentary behaviour coupled with the stress experienced during the pandemic may impair the immune system of older adults and increase their risk of infection (Damiot et al., 2020). The consequences of inactivity and sedentary behaviours give a strong reason for older adults to engage in physical activity to stay healthy in the current pandemic.

2.14.3 Retirement villages and COVID-19

Some older adults choose to live in retirement villages. Living in retirement villages provides older adults with opportunities to engage in on-site leisure activities (e.g., line dancing), sports activities (e.g., croquet) or use fitness facilities (e.g., gym) (Hu et al., 2017). Cancellation of leisure activities (e.g., line dancing) and sports activities, and the closure of fitness facilities during lockdown reduced opportunities for older adults living in retirement villages to be physically active.

Given the growth of retirement village living as a lifestyle choice for older Australians, there is merit in exploring older adults' experiences living in retirement villages during the COVID-19 lockdown, if and how they continued to be physically active during the pandemic, and the types of physical activity that interested them and were able to be participated in, while they were practicing physical distancing. Therefore, exploring how older adults living in retirement villages coped, and whether and how they continued their physical activity is important for health professionals, government, retirement villages and local councils to understand, so that they can ensure strategies and resources are available to provide support for maintaining physical activity during future pandemics, and more generally.

2.14.4 Rationale for exploring the experiences of older adults during COVID-19 in retirement village settings

Older adults are a heterogeneous group. Older adults living in retirement villages may have different preferences when participating in physical activity during the COVID-19 pandemic compared to older people living in different settings, such as living in their own homes in the community. To date, no studies have explored the physical activity experiences of older adults living in retirement villages during the lockdown period.

2.15 Summary of research gaps and thesis studies to address these gaps

Participation in physical activity is important to maintaining health for older adults. However, a high proportion of older adults do not engage in adequate physical activity, including multi-modal activities. Outdoor exercise parks could be an avenue for older adults to increase physical activity participation and engage in multi-modal activities.

Previous systematic reviews reported that individuals use outdoor exercise parks to improve their health and see them as opportunities for social interaction (Lee et al., 2018) and outdoor exercise parks may improve physical performance and fitness among individuals (Jansson et al., 2019). These two systematic reviews summarised the usage and health benefits across all age groups and did not focus on older adults. There is a need to investigate the use and effectiveness of outdoor exercise parks on physical function, physical activity, psychosocial and quality of life outcomes, particularly among older adults (aged 60 years or older) (Ng, Hill, Levinger, et al., 2021)(Chapter 4 in this thesis) as their health challenges often differ to those of younger populations.

Older adults who are higher functioning are often not targeted for early preventive intervention, although they may experience a mild deterioration in their balance abilities (Yang et al., 2011). Early assessment and intervention are important for this group of older adults to prevent falls and further deterioration of their balance.

Several balance and mobility tests are prone to ceiling effects, which may limit the ability of the test to identify older adults with early changes in balance and mobility and evaluate intervention effectiveness over time (Bergquist et al., 2019; Langley & Mackintosh, 2007; Power et al., 2014). The CBMS appears to be a useful tool that is not susceptible to ceiling effects (Balasubramanian, 2015; Weber et al., 2018), but does have some practical limitations when used in the community due to the requirement of a long walkway (i.e., eight metres) and a flight of stairs. A modified version of the CBMS to enable use in the homes of older people was developed and is evaluated in Chapter 5 of this thesis.

Previous studies revealed that older adults who are generally well improved their physical performance and reduced the incidence of falls after participating in supervised Seniors Exercise Park training (Levinger et al., 2022; Levinger et al., 2020; Sales et al., 2017). In addition, the authors reported that Seniors Exercise Parks were a feasible and safe training approach for older adults. To date, no research has evaluated supervised Seniors Exercise Park training, and unsupervised and independent Seniors Exercise Park practice among older adults with mild balance dysfunction (Chapters 6 and 7).

The COVID-19 pandemic delayed the commencement of the Seniors Exercise Park studies (Chapters 6 and 7) in this thesis by six months. This delay presented an opportunity to understand the physical activity experiences of older adults during COVID-19. Older adults' physical activity participation in Australia, Europe, Japan, and North America have been reported to be affected during the COVID-19 pandemic (Callow et al., 2020; Kunstler et al., 2020; Visser et al., 2020; Yamada et al., 2020). However, less is known about the physical activity experiences of older adults living in retirement villages. Chapter 8 explores the experiences and impact of COVID-19 lockdown on physical activity among older adults living in retirement villages.

The studies in this thesis address these important gaps and inform approaches to improve physical activity for older people.

Chapter 3 : Methods

Chapter outline

This chapter provides an overview of the research methods used in four studies included in this thesis. Chapters four to eight consist of individual peer-reviewed publications and manuscripts prepared for review. The purpose of this chapter is to provide additional information not able to be reported in the manuscripts of each study due to word limitations imposed by different peer-reviewed journals.

3.1 The setting

All four studies recruited community-dwelling older people living in Perth, Western Australia. Western Australia is a state in Australia with approximately 2.5 million people, and this number is estimated to increase to 3.4 million people by 2031 (Department of Planning Lands and Heritage, 2019). The proportion of people aged 65 years and over is expected to increase by 3.6% by 2031 (Department of Planning Lands and Heritage, 2019). The majority of the participants in the studies in this thesis lived in Bentley, one of the suburbs in Perth, with a population of 9,051 people (Australian Bureau of Statistics, 2021). About 21.4% of the population in Bentley are aged 65 years and over (Australian Bureau of Statistics, 2021). The participants resided at two large retirement villages in Bentley, or in the community. Residents at the retirement villages lived in independent units such as terrace houses, apartments, or villas and had access to services and onsite security, fitness facilities such as a swimming pool, lawn bowls or gym, and activities, for example, line dancing. Participants in the community lived in apartments or houses.

3.2 Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment

3.2.1 Study design

This research is a reliability and validity study.

3.2.2 Study population and sample

The CBMS is quite a challenging outcome measure that evaluates balance, gait, and mobility performance in older adults and is sensitive to assessing mild levels of balance impairments (Balasubramanian, 2015). Older adults (i.e., aged 65 years or older) living independently in the community at a retirement village or in their own home were recruited as they were likely to be generally well, but some may have experienced mobility and/or balance impairments (and therefore be suitable for the relatively challenging tasks in CBMS).

Older people not able to read, understand, or write in English were excluded from the research, as it was not possible to confirm their ability to consent their participation, and interpreters were not a viable option within the PhD budget. In addition, the inability to understand instructions and perform the tests as instructed during the assessment may have put the individual at risk of a fall or other injuries. Older people who required supervision or assistance during daily activities such as transfers, standing up and walking, or using a wheelchair for mobility indoors or outdoors were deemed not eligible because they were at higher risk of an adverse event occurring, such as a fall or injury, as well as being likely to be unable to perform several of the CBMS tasks.

3.2.3 Study setting

The assessments were conducted in the homes of participants if they agreed and had adequate space to test the original and modified items of CBMS or at one of the retirement villages that had adequate space in common areas (i.e., a space of at least 10 metres by two metres) and stairs. Many of the participants (n = 53 (96.3%)) completed their assessment sessions in the activity room at the retirement village (stairs were just outside this room). Two (3.7%) of the participants completed theirs in their homes in the community.

3.2.4 Recruitment and data collection

Participants were recruited from the community and retirement village. The publicity of the research was through flyers distributed at the retirement village and public areas (e.g., bus stops, researchers' neighbours), a research volunteer database, and word of mouth. A brief description of the study was provided to interested participants, and detailed information was emailed or given to the participants where further information was asked. A follow-up phone call was performed to screen participants over the phone to determine their eligibility for the study and to identify their existing medical conditions, so that necessary precautions could be undertaken during the assessment. During the phone call, if the participant acknowledged having these medical conditions (e.g., heart conditions, high blood pressure, and bone, joint or soft tissue problems) and symptoms (chest pain during daily activities, loss of balance because of dizziness or consciousness), follow-up questions were asked to determine the severity of the condition. The participant would be excluded from the study if their medical condition (e.g., unstable angina) or symptoms (e.g., falls caused by complaints of dizziness) were determined as a contraindication to exercise (Laddu et al., 2015).

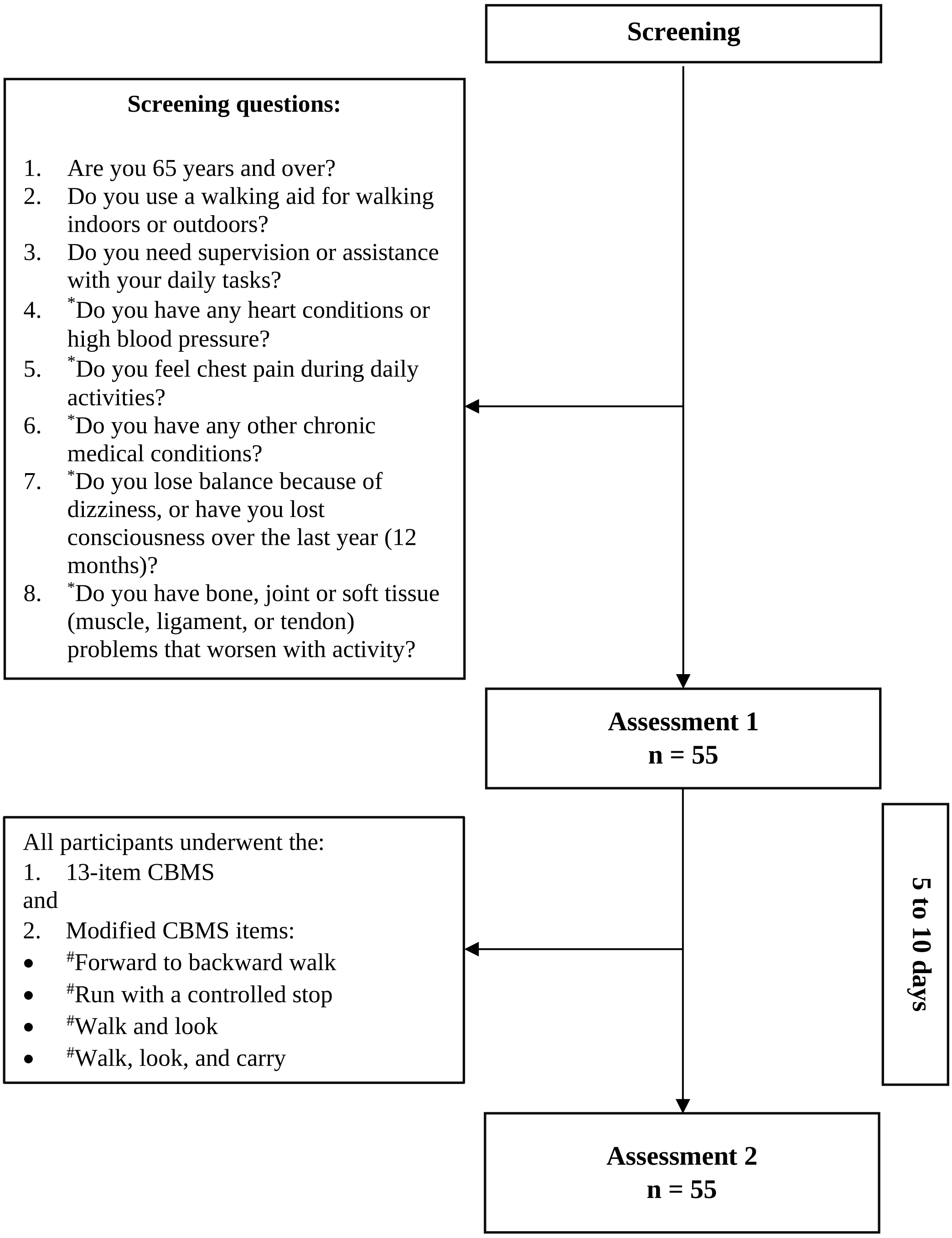
An appointment was made to meet the participant at their home in the community or the activity room at the retirement village, if they met all the study inclusion criteria. At this appointment, the participant read the participant information sheet (See Appendix 1) and gave informed consent before the commencement of data collection.

Participants completed their demographic (e.g., age, marital status, and living status) and background information (e.g., falls in the previous year, weight, height). Participants wore comfortable flat shoes and a safety gait belt (to assist them if they lost their balance) during the tests described in section 3.2.6 below. Participants rested as many times as required between the tasks. The participants returned five to 10 days later after the first visit. The first visit took up to one and a half hours, and the second visit took up to an hour (See Figure 3.1).

3.2.5 Sample size

The sample size was described in the published paper (Chapter 5).

Figure 3.1. Study flow



Note. CBMS = Community Balance and Mobility Scale; n = number of participants.

[*]Questions adapted from Warburton D., Bredin S., Jamnik V., Gledhill N. Warburton, D. E. R., Bredin, S. S. D., Jamnik, V. K., & Gledhill, N. (2011). Validation of the PAR-Q+ and ePARmed-X+. *The Health & Fitness Journal of Canada*, *4*(2), 38-46. https://doi.org/10.14288/hfjc.v4i2.151.

[#]Length of walkway was adjusted to four metres.

3.2.6 Outcome measures and measurement procedures

The section below describes the information and procedure for each outcome measure (See Table 3.1 for a summarised list of the outcome measures used for this study). All outcome measures were conducted in the same order of assessment by one researcher (i.e., PhD student). All participants underwent the 13-item original CBMS and four additional modified items of the CBMS, as well as the Functional Reach Test (Duncan et al., 1990; Rosa et al., 2019) and Step Test (Hill, Bernhardt, et al., 1996).

The researcher demonstrated the task first to ensure the participant understood how to perform the items. The researcher repeated the instructions if the participant did not understand the task. The score was recorded as "zero - unable" (i.e., the lowest score for that item) if the participant did not complete the test item safely and independently. The participants completed all tests without using a walking aid except for the test item 'descending stairs' for the CBMS (where the use of a walking stick or aid was permitted).

Table 3.1. Summary of the screening tests and outcome measures used in the CBMS study (Reliability and validity study, Chapter 5) and Seniors Exercise Park study (Pre-post intervention study, Chapters 6 and 7)

Assessment	Type of study					
	Reliability and validity study		Pre-post intervention study			
	Visit 1	Visit 2	Screening	Baseline	After week 18	After week 24
Demographic Information (Age, sex, education etc.)	✓			✓		
Background Information (Number of falls past one year, height, weight etc.)	✓			✓		
Questionnaires						
*Physical Activity Readiness Questionnaire for Everyone (PARQ+)			✓			
*Abbreviated Mental Test Score			✓			
European Quality of Life Scale-5D (EQ-5D-5L)				✓	✓	✓
Modified Falls Efficacy Scale				✓	✓	✓
Physical Activity Scale for the Elderly				✓	✓	✓
UCLA Three-Item Loneliness Scale				✓	✓	✓
Self-Efficacy Scale for Exercise				✓	✓	✓
Five-Item World Health Organisation Well-Being Index				✓	✓	✓
Physical Performance Measures						
CBMS	✓	✓				
CBMS-Home	✓	✓		✓	✓	✓
Fast Gait Speed Test				✓	✓	✓
Four Square Step Test				✓	✓	✓
Five Times Sit to Stand				✓	✓	✓
Functional Reach Test	✓	✓		✓	✓	✓
Step Test	✓	✓		✓	✓	✓
Qualitative						
Semi-structured interview					✓	✓

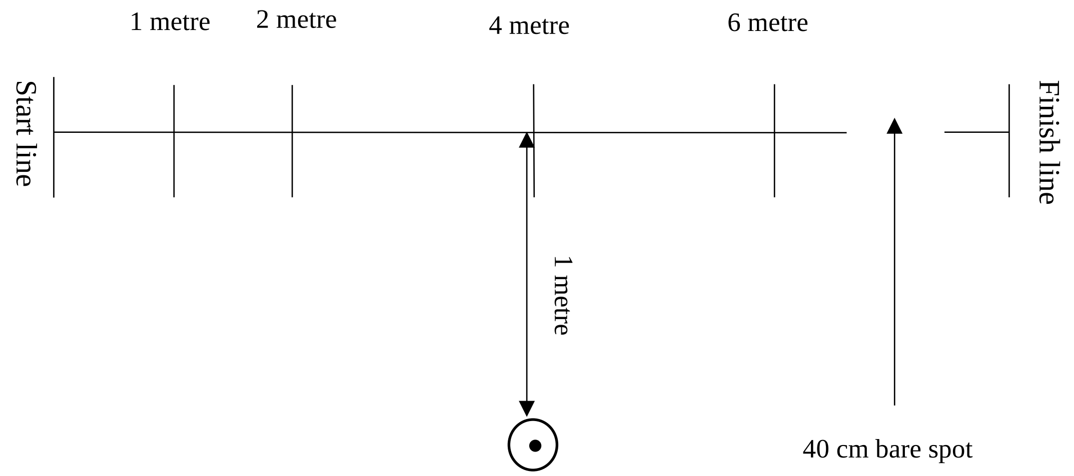
Note. CBMS = Community Balance and Mobility Scale; CBMS-Home = Modified Community Balance and Mobility Scale.

*The PARQ+ and Abbreviated Mental Test were conducted for the pre-post intervention study.

3.2.6.1 CBMS

The items of the CBMS, as well as the reliability and validity of the CBMS, were covered in the literature review (Section 2.9.6). Participants were scored on the first trial of the CBMS as recommended by the authors and developers of the CBMS. All participants performed the 13-item original CBMS (Howe et al., 2011). The participants were directed using standardised instructions provided by the original authors of the CBMS (Howe et al., 2011). All participants stood with their arms at their sides, feet positioned slightly apart, and toes touched the track's starting line unless otherwise indicated. The set-up of the track (see Figure 3.2), item instructions and scoring of the original 13-item CBMS are described (see Table 3.2).

Figure 3.2. Set up of the track for Community Balance and Mobility Scale



Note. The track is an eight metre line. The one metre, two metre, four metre and six metre points should be marked. The visual target for items 'Walk and look' and 'Walk, look and carry' is positioned at the four metre mark. The visual target should be positioned at participants' eye level. The track was adapted from Howe, J. A., & Inness, E. L. (2011). *Community Balance and Mobility Scale*. Toronto Rehab. Retrieved June 25, 2021, from https://sites.temple.edu/rtassessment/files/2018/10/Community-Balance-and-Mobility-Scale-Instructions.pdf.

Table 3.2. Community Balance and Mobility Scale (CBMS) and CBMS-Home

CBMS Task	Length of walkway		Task Instructions		Scoring	
	Original CBMS	**CBMS-Home**	**Original CBMS**	**CBMS-Home**	**Original CBMS**	**CBMS-Home**
Unilateral stance (Bilateral)	Not applicable	No change	"Stand on your right/left leg and hold for as long as you can up to 45 seconds. Look straight ahead."	No change	0: unable to sustain 1: 2.00 to 4.49 sec. 2: 4.50 to 9.99 sec. 3: 10.00 to 19.99 sec. 4: ≥ 20.00 secs. 5: 45.00 sec., steady and coordinated	No change
Tandem walking	~2 metres	No change	"Walk forward on the line, heel touching toes. Keep your feet pointing straight ahead. Look ahead down the track, not at your feet. I will tell you when to stop."	No change	0: unable 1: 1 step 2: 2 to 3 consecutive steps 3: > 3 consecutive steps, toe out is allowed 4: > 3 consecutive steps, in good position (heel to toe contact, no toe out) and increased use of equilibrium reactions 5: 7 consecutive steps	No change
180° tandem pivot (Task is done on the 40 cm bare spot)	< 1 metre	No change	"Lifting your heels just a little, pivot all the way around to face the opposite direction without stopping. Put your heels down and maintain your balance in this position."	No change	0: unable to sustain tandem stance 1: sustains tandem stance but unable to unweight heels or initiate pivot 2: initiates pivot but unable to complete 180° turn 3: completes 180° turn but discontinuous pivot (e.g., pauses on toes) 4: completes 180° turn in a continuous motion but can't sustain reversed position 5: completes 180° turn in a continuous motion and sustains reversed position	No change
Lateral foot scooting (Bilateral) (Task is done on the 40 cm bare spot)	< 1 metre	No change	"Stand on your right/left leg and move sideways by alternately pivoting on your heel and toe. Keep pivoting straight across until you touch the line and maintain your balance in this position."	No change	0: unable 1: 1 lateral pivot 2: 2 lateral pivots 3: ≥ 3 pivots but < 40 cm 4: 40 cm in any fashion and/or unable to control final position 5: 40 cm continuous, rhythmical motion with controlled stop	No change

Table 3.2. Continued

CBMS Task	Length of walkway		Task Instructions		Scoring	
	Original CBMS	**CBMS-Home**	**Original CBMS**	**CBMS-Home**	**Original CBMS**	**CBMS-Home**
Hopping forward (Bilateral)	1 metre	No change	"Stand on your right/left foot. Hop twice straight along this line to pass the 1metre mark with your heel. Maintain your balance on your right/left leg at the finish."	No change	0: unable 1: 1 to 2 hops, uncontrolled 2: 2 hops, controlled but unable to complete 1 metre 3: 1 metre in 2 hops but unable to sustain landing (touches down) 4: 1 metre in 2 hops but difficulty controlling landing (hops or pivots) 5: 1 metre in 2 hops, coordinated with stable landing	No change
Crouch and walk	4 metres	No change	"Walk forward and, without stopping, bend to pick up the bean bag and then continue walking down the line."	No change	0: unable to crouch 1: able to descend only 2: descends and rises but hesitates, unable to maintain forward momentum 3: crouches and walks in continuous motion, time ≤ 8.00 sec. protective step 4: crouches and walks in continuous motion, time ≤ 8.00 sec. excess equilibrium reaction 5: crouches and walks in continuous motion, time ≤ 4.00 sec.	No change
Lateral dodging	2 metres	No change	"Move sideways along the line by repeatedly crossing one foot in front of and over the other. Place part of your foot on the line with every step. Reverse direction whenever I call "Change!" Do this as fast as you can, yet at a speed that you feel safe."	No change	0: unable to perform 1 cross-over in both directions without support 1: 1 cross-over in both directions in any fashion 2: 1 or more cycles, but does not contact line every step 3: 2 cycles, contacts line every step 4: 2 cycles, contacts line every step 12.00 to 15.00 sec. 5: 2 cycles, contacts line every step < 12.00 sec. coordinated direction change	No change

Table 3.2. Continued

CBMS Task	Length of walkway		Task Instructions		Scoring	
	Original CBMS	**CBMS-Home**	**Original CBMS**	**CBMS-Home**	**Original CBMS**	**CBMS-Home**
Step ups x 1 step (Bilateral)	Not applicable	No change	"Step up and down on this step as quickly as you can until I say "Stop." The pattern is Right-Left Up and Right-Left Down. Try not to look at your feet. Step up and down on this step as quickly as you can until I say "Stop." The pattern is Left-Right Up and Left-Right Down. Try not to look at your feet."	No change	0: unable to step up, requires assistance or railing 1; steps up, requires assistance or railing to descend 2: steps up and down (1 cycle) 3: completes 5 cycles 4: completes 5 cycles in > 6.00 but < 10.00 sec. 5: completes 5 cycles in ≤ 6.00 sec., rhythmical	No change
*Forward to backward walking .	8 metres	**4 metres**	"Walk as quickly as you can yet at a speed that you feel safe." *The participant is to turn at the 4 metre mark. It is acceptable for the subject to turn in any direction she/he chooses	"Walk as quickly as you can yet at a speed that you feel safe." *The participant is to turn at the **2 metre** mark. It is acceptable for the subject to turn in any direction she/he chooses.	0: unable 1: performs but must stop to regain balance 2: performs with reduced speed, time > 11.00 sec. or requires 4 or more steps to turn 3: performs in ≤ 11.00 sec. and/or veers during backward walking 4: performs in ≤ 9.00 sec. and/or uses protective step during or just after turn 5: performs in ≤ 7.00 sec., maintains straight path	0: unable 1: performs but must stop to regain balance 2: performs with reduced speed, time **> 5.50 sec**. or requires 4 or more steps to turn 3: performs in ≤ **5.50 sec**. and/or veers during backward walking 4: performs in ≤ **4.50 sec**. and/or uses protective step during or just after turn 5: performs in ≤ **3.50 sec.**, maintains straight path

Table 3.2. Continued

CBMS Task	Length of walkway		Task Instructions		Scoring	
	Original CBMS	**CBMS-Home**	**Original CBMS**	**CBMS-Home**	**Original CBMS**	**CBMS-Home**
*Running with a controlled stop	8 metres	**4 metres**	"Run as fast as you can." Hold position on finish line.	"Run as fast as you can." Hold position on finish line.	0: unable to run 1: runs, time > 5.00 sec. 2: runs, time > 3.00 but ≤ 5.00 sec., unable to control stop 3: runs, time > 3.00 but ≤ 5.00 sec., with controlled stop, both feet on line 4: runs, time ≤ 3.00 sec., unable to control stop 5: runs, time ≤ 3.00 sec., with controlled stop, both feet on line, coordinated and rhythmical	0: unable to run 1: runs, time > **2.50 sec.** 2: runs, time > **1.50 sec. but ≤ 2.50 sec.,** unable to control stop 3: runs, time **> 1.50 sec. but ≤ 2.50 sec.**, with controlled stop, both feet on line 4: runs, time ≤ **1.50 sec.,** unable to control stop 5: runs, time ≤ **1.50 sec.,** with controlled stop, both feet on line, coordinated and rhythmical
*Walk and look (Bilateral)	8 metres	**4 metres**	"Walk at your usual pace." 1. At the 2 metre mark, ask the patient to "Look at the circle." 2. Cue the patient to "Keep looking at the circle" as they look back over their shoulder until they reach the 6 metre mark. 3. At the 6 metre mark, ask the patient to "Look straight ahead and continue walking until the end of the line."	"Walk at your usual pace." 1. At the **1 metre** mark, ask the patient to "Look at the circle." 2**.** Cue the patient to "Keep looking at the circle" as they look back over their shoulder until they reach the **3 metre** mark. 3. At the **3 metre** mark, ask the patient to "Look straight ahead and continue walking until the end of the line."	0: unable to walk and look e.g., stops 1: performs but loses visual fixation at or before 4 metre mark 2: performs but loses visual fixation after 4 metre mark 3: performs and maintains visual fixation between 2-6 metre mark but protective step 4: performs and maintains visual fixation between 2-6 metre mark but veers 5: performs, straight path, steady and coordinated ≤ 7.00 sec.	0: unable to walk and look e.g., stops 1: performs but loses visual fixation at or before **2 metre** mark 2: performs but loses visual fixation after **2 metre** mark 3: performs and maintains visual fixation between **1-3 metre** mark but protective step 4: performs and maintains visual fixation between **1 -3 metre** mark but veers 5: performs, straight path, steady and coordinated ≤ **3.50 sec.**

Table 3.2. Continued

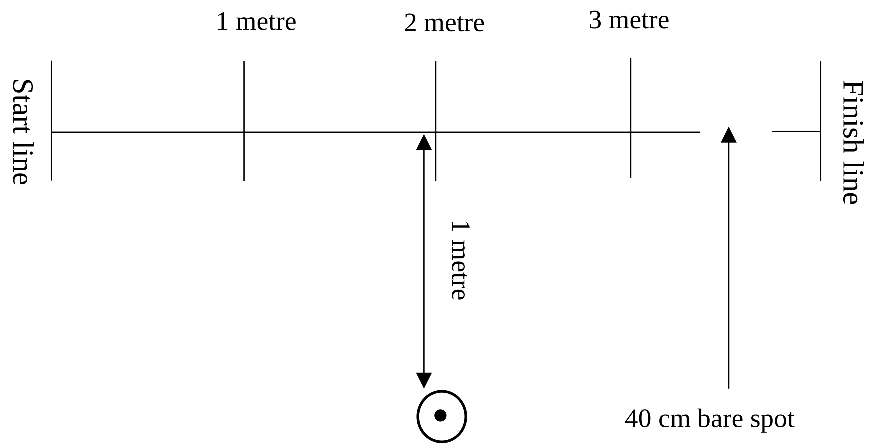
CBMS Task	Length of walkway		Task Instructions		Scoring	
	Original CBMS	**CBMS-Home**	**Original CBMS**	**CBMS-Home**	**Original CBMS**	**CBMS-Home**
*Walk, look and carry (Bilateral) - Carry 2 grocery bags of 3.4kg each.	8 metres	**4 metres**	"Walk at your usual pace." 1. At the 2 metre mark, ask the patient to "Look at the circle." 2. Cue the patient to "Keep looking at the circle" as they look back over their shoulder until they reach the 6 metre mark. 3. At the 6 metre mark, ask the patient to "Look straight ahead and continue walking until the end of the line."	"Walk at your usual pace." 1. At the **1 metre** mark, ask the patient to "Look at the circle." 2. Cue the patient to "Keep looking at the circle" as they look back over their shoulder until they reach the **3 metre mark.** 3. At the **3 metre** mark, ask the patient to "Look straight ahead and continue walking until the end of the line."	0: unable to walk and look e.g., stops 1: performs but loses visual fixation at or before 4 metre mark 2: performs but loses visual fixation after 4 metre mark 3: performs and maintains visual fixation between 2-6 metre mark but protective step 4: performs and maintains visual fixation between 2-6 metre mark but veers 5: performs, straight path, steady and coordinated ≤ 7.00 sec.	0: unable to walk and look e.g., stops 1: performs but loses visual fixation at or before **2 metre** mark 2: performs but loses visual fixation after **2 metre** mark 3: performs and maintains visual fixation between **1-3 metre** mark but protective step 4: performs and maintains visual fixation between **1 -3 metre** mark but veers 5: performs, straight path, steady and coordinated ≤ **3.50 sec.**
*Descending stairs +1 bonus mark for carrying basket.	Minimum of 8 steps on a flight of stairs	**This item was removed**	"Walk down the stairs. Try not to use the railing".	**This item was removed**	0: unable to step down 1 step, or requires railing or assistance 1: able to step down 1 step with/without cane 2: able to step down 3 steps with/without cane, any pattern 3: 3 steps reciprocal or full flight in step-to pattern 4: full flight reciprocal, awkward 5: full flight reciprocal, rhythmical and coordinated	**This item was removed**

Note. sec. = seconds; *0.50 sec. = 500 milliseconds. Bold text in the table indicates modifications made to the original CBMS for the CBMS-Home. Item instructions and scoring is modified and adapted from Howe, J.A., & Inness, E. L. (2011). *Community Balance and Mobility Scale*. Toronto Rehab. Retrieved June 25, 2021, from https://sites.temple.edu/rtassessment/files/2018/10/Community-Balance-and-Mobility-Scale-Instructions.pdf.

3.2.6.2 Modified Community Balance and Mobility Scale (CBMS-Home)

For the purpose of being used in an assessment in a typical-sized home, the CBMS was modified by (1) reducing the length of the walkway used in four items (i.e., from eight metres to four metres) and (2) changing the scoring criteria for the five-point scales (i.e., duration to complete the item was halved) for these items (Ng, Hill, Jacques, et al., 2021). These four modified CBMS items using the four metre walkway and included 'walk and look', 'walk, look, and carry', 'run with a controlled stop', and 'forward to backward walk' (Ng, Hill, Jacques, et al., 2021). Therefore, the CBMS-Home (modified CBMS) consisted of four modified items and eight original items of the CBMS conducted on the shorter walkway. The item 'descending stairs' was removed because not every home has eight steps on a flight of stairs that can be used to perform this task. The set-up of the track (see Figure 3.3), item instructions, and the scoring of CBMS-Home are described (see Table 3.2).

Figure 3.3. Set up of the track for the Community Balance and Mobility Scale-Home



Note. The track is a four metre line. The one metre, two metre, three metre points should be marked. The visual target for items 'Walk and look' and 'Walk, look and carry' is positioned at the two metre mark. The visual target should be positioned at a participants' eye level. The track was modified from Howe, J.A., & Inness, E. L. (2011). *Community Balance and Mobility Scale*. Toronto Rehab. Retrieved June 25, 2021, from https://sites.temple.edu/rtassessment/files/2018/10/Community-Balance-and-Mobility-Scale-Instructions.pdf and adapted from Ng, Y.L., Hill, K.D., Jacques, A., & Burton, E. (2021). Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment. *Physical Therapy*, 101(8), 1-10.

3.2.6.3 Functional Reach Test

The Functional Reach Test is a dynamic standing balance test (Duncan et al., 1990) often used with older people (Duncan et al., 1990; Rosa et al., 2019) and older people with medical conditions such as stroke (Smith et al., 2004) and Parkinson's disease (Schenkman et al., 2011). The Functional Reach Test measures the maximum distance an individual reaches forward during standing without assistance from another person or taking a step (Duncan et al., 1990). For the studies in this thesis, participants stood next to a wall with a tape measure attached to the wall at their shoulder height, they raised their dominant and best functioning arm to 90 degrees of shoulder flexion with a closed fist throughout the test, and feet were positioned 10 cm apart (Hill et al., 1997).

The researcher instructed each participant to "*Reach as far as you can forward without taking a step*". Participants practiced once before the actual measurement. Participants then performed the Functional Reach Test twice. The difference between the starting point and the endpoint of the third metacarpal in centimetres was reported. The mean distance of the two Functional Reach Test measurements was reported.

The Functional Reach Test demonstrated excellent test-retest reliability ($ICC_{1,3}$ = 0.92) when the test was conducted on two separate occasions one week apart on 128 healthy people (age 21-87 years) (Duncan et al., 1990). The Functional Reach Test was also positively correlated to electronic forward reach (r (127) = .69), and the centre of pressure excursion (r (127) = .71) (Duncan et al., 1990).

A systematic review of the Functional Reach Test evaluated factors that could influence the assessment method and determined the normative values for older people (Rosa et al., 2019). The Functional Reach Test average value was 15.4 cm, 95% CI [13.5, 17.4] for non-community older people (e.g., hospitals, long-term care) and 26.6 cm, 95% CI [25.1, 28.1] for community-dwelling older people across various health conditions (Rosa et al., 2019). The strategies used to perform the reach task, such as trunk rotation, or hip or ankle strategy, may influence the ability and scores achieved as older people reach forward during this test (Rosa et al., 2019).

3.2.6.4 Step Test

The Step Test evaluates the speed of a person performing a dynamic single limb stance while stepping on and off a block (Hill, Bernhardt, et al., 1996). It measures the number of times a participant places their whole foot on the 7.5 cm block (positioned in front of the participant) and then off the block back onto the floor as quickly as possible in 15 seconds. One completed step consists of placing the foot on the block and then back onto the floor (to the starting position). The test is then repeated with the other leg. Before the start of the test, participants were allowed several practice steps. The block was positioned against the wall to prevent the block from moving during the test. The participant was instructed to "*Place your whole foot on the block and return it fully back to the floor as fast as possible when I say 'go'. Ready, go.*" The researcher started the measurement period by instructing "go" and indicated the end of the measurement period by saying "stop". A stopwatch was used for timing the task.

The Step Test scores were similar between the two legs stepping on and off the block for many participants. However, there can be a considerable difference in unilateral conditions affecting the lower limbs, such as stroke or arthritis. Different strategies have been reported for managing different performance (scores) between the right and left (or affected/unaffected) legs by deriving a single score for analysis and interpretation, instead of two separate scores. The lower score between the two legs is likely to reflect the level of balance impairment better than other approaches, such as calculating the average score between the two legs. Hill, Bernhardt, et al. (1996), the authors who developed the Step Test and other studies (Suttanon et al., 2018; Yang et al., 2011; Yang et al., 2012), have previously reported the worst leg score. Therefore, the lower score was used for data analysis in this thesis.

Forty-one older people who were healthy and 41 older people who had a stroke participated in the development of the Step Test (Hill, Bernhardt, et al., 1996). The test-retest reliability was high for a subgroup of 14 healthy older adults ($ICC_{3,1} > 0.90$) and 21 older adults after stroke ($ICC_{3,1} > 0.88$) (Hill, Bernhardt, et al., 1996). The normative value of the Step Test for healthy older people was 17.4 (SD = 3.0) steps in 15 seconds (Hill, Bernhardt, et al., 1996). The Step Test correlated significantly with gait stride length, gait velocity, and the Functional Reach Test ($p < .001$) (Hill, Bernhardt, et al., 1996). In another study, a moderate positive correlation was reported between the Step Test and the Four Square Step Test (r_s (80) = .50, $p < .001$) (Dite & Temple, 2002). Men scored higher than women on the Step Test, and the Step Test values declined with increasing age (Isles et al., 2004; Nolan et al., 2010).

3.2.7 Data analysis

The CBMS has already been shown to be valid against several recognised, validated balance and mobility measures such as Berg's Balance Scale (Balasubramanian, 2015; Takacs et al., 2014), the dynamic gait index (Balasubramanian, 2015), the Short Performance Physical Battery (Balasubramanian, 2015), self-selected gait speed (Balasubramanian, 2015; Takacs et al., 2014; Weber et al., 2018), fast gait speed (Takacs et al., 2014), timed up and go test (Takacs et al., 2014; Weber et al., 2018), single leg stance time (Takacs et al., 2014), and The Fullerton Advanced Balance Scale (Weber et al., 2018). Therefore, this study used two commonly used tests assessing differing aspects of balance / mobility (Functional Reach Test, evaluating limits of stability / dynamic balance on a fixed base of support; and the Step Test, evaluating a moderately challenging dynamic stepping task) to indicate the validity of the CBMS and CBMS-home. Further information on data analysis is described in the published paper found in Chapter 5.

3.3 Seniors Exercise Park program for older adults with mild balance dysfunction − A feasibility study

3.3.1 Study design

This study design was a quasi-experimental one-group pre-and post-intervention study, with the outcomes measured before and after the intervention and again after a subsequent unsupervised period of participation. This study design was used to assess the feasibility (including safety and effects) of an exercise program using a Seniors Exercise Park for older people with mild balance dysfunction. Six domains of feasibility as described by Bowen et al. (2009) were evaluated, which included demand, implementation, practicality (including safety), efficacy testing, adaptation, and acceptability. These domains are described in more detail in Chapter 6, which reports the methods and results of this study.

3.3.2 Study population and sample

Recruitment targeted older adults (i.e., aged 65 years or older) living independently in the community using no more than a single-point stick, not engaging in 30 minutes of moderate intensity physical activity on most days/daily (i.e., Total duration moderate intensity physical activity: < 150 minutes per week), and/or expressing concerns about balance and experiencing no more than one fall in the last 12 months (see Chapter 6 for details of inclusion criteria). Although recruitment targeted community settings broadly (both people living in their own homes, and those living independently in retirement villages, including regular publicity by 'The Town of Victoria Park' council from November 2020 until June 2021, there were no volunteers recruited for this study who did not live in a retirement village. This retirement village had a Seniors Exercise

Park recently installed on its site. The COVID-19 pandemic may have contributed to a lack of community participation during this time.

3.3.3 Study setting

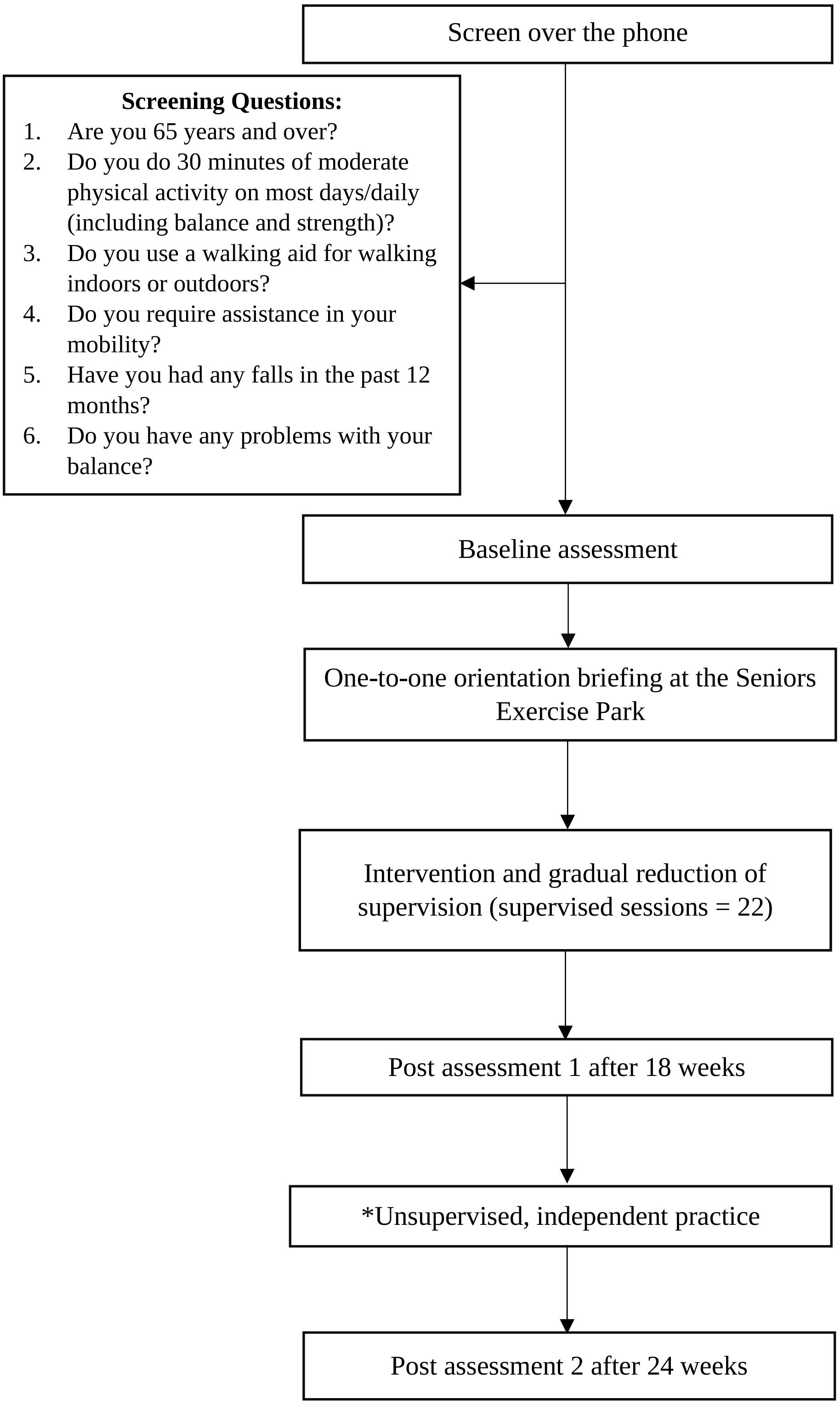
Assessments were conducted before the intervention commenced, after week 18, and after week 24 in a room close to the Seniors Exercise Park at the retirement village. The 18 week supervised Seniors Exercise Park intervention was carried out at the Seniors Exercise Park located at the retirement village.

3.3.4 Recruitment and data collection

Forty-six participants were recruited through flyers distributed at the retirement village and community, speaking to residents after their activity sessions at the retirement village, e-mailing participants who agreed to be contacted from a research database, and word of mouth. Seventeen (37%) participants who entered the Seniors Exercise Park program participated in the previous studies.

Interested participants either phoned or e-mailed the research team and were provided with detailed information about the study (see Appendix 2). A follow-up phone call was made to screen participants over the phone to determine their eligibility for the study. If the participant met all the inclusion criteria, an appointment was arranged to meet the participant at the retirement village (i.e., a room close to Senior Exercise Park). At this appointment, written consent was obtained from the participant before the commencement of data collection. Figure 3.4 summarises the flow of the study.

Figure 3.4. Pre-post intervention study flow



Note. * = Participants could choose to meet the physiotherapist at the Seniors Exercise Park if they had any issues or concerns.

Participants completed their demographic (e.g., age, marital status, living status) and background information (e.g., weight, height, person to contact during an emergency) and outcome measures (see Section 3.3.9 and 3.3.10) during this appointment. Participants wore comfortable flat shoes and a safety gait belt (so that the researcher could assist them if they lost their balance) during the assessment. Participants rested as many times as required between the tasks. Participants were classified as having mild balance dysfunction if their performance on one or both of the Step Test and/or the Functional Reach Test was below the cut-off score for respective age ranges based on research by Williams et al. (2015) (See Table 3.3).

Table 3.3. Classification of mild balance dysfunction

	Cut-off scores		
	Older adults with mild balance dysfunction		**Older adults with severe balance dysfunction**
Tests	**Aged 65-75 years**	**Aged >75 years**	**Aged >65 years**
FRT	# < 29cm	# < 27cm	* < 18 cm
ST	# < 17steps/15 sec	#< 15steps/15 sec	** < 11 steps/15 sec

Note. FRT = Functional Reach Test; ST = Step Test.

Adapted from #Williams S., Meyer C., Batchelor F., & Hill K. Exercise for mild balance dysfunction: Research into practice (2015). *Journal of Aging and Physical Activity*, *23*(4), 590. https:/doi.org/10.1123/japa.2014-0182.

*Weiner, D. K., Duncan, P. W., Chandler, J., & Studenski, S. A. (1992). Functional reach: A marker of physical frailty. *Journal of American Geriatrics Society*, *40*(3), 203-207. https://doi.org/10.1111/j.1532-5415.1992.tb02068.x.

**Dite, W., & Temple, V. A. (2002). A clinical test of stepping and change of direction to identify multiple falling older adults. *Archives of Physical Medicine and Rehabilitation*, *83*(11), 1566-1571. https://doi.org/10.1053/apmr.2002.35469.

On the same day of the assessment or another day (dependent on the participant's availability or weather), the participant was given a one-to-one orientation session at the Seniors Exercise Park of up to 30 minutes to determine the most appropriate starting level of exercise (See Appendix 3). Participants returned after 18 weeks and

24 weeks and repeated the same measurements as those undertaken during the baseline testing (i.e., standardised questionnaires and physical performance measures).

3.3.5 The Seniors Exercise Park intervention

The Seniors Exercise Park is described in detail in Chapter 6. The exercises at the Seniors Exercise Park prescribed for each participant were individualised by the researcher (physiotherapist) based on the results of the initial assessment and the initial orientation of the participant with the Seniors Exercise Park equipment. Exercises were made progressively more challenging as each participant improved. The exercises prescribed were adapted from Sales et al. (2015). A copy of the exercises is included in Appendix 4. Older people with mild balance dysfunction underwent 22 supervised sessions over the 18 week supervised period. The ratio of the physiotherapist to participant was a maximum of 1:8 for the mild balance dysfunction group Seniors Exercise Park classes. Participants underwent an 18 week, one-hour, twice-weekly exercise program (with supervision reduced over time), so they gradually increased independent practice sessions in between less frequent supervised sessions.

At the end of each supervised exercise class, light refreshments were provided to the participants to encourage social interaction. Exercise sessions were cancelled and replaced with another day if there were severe weather conditions (e.g., rain or extreme heat). In the last three supervised sessions for each group prior to the end of the supervised 18 week period, up to 30 minutes of each session was spent preparing participants for independent Seniors Exercise Park use. Handouts were given and discussed to support this transition. A copy of the handout can be found in Appendix 5.

Participants were provided with information about safety measures and guided information on using the Seniors Exercise Park equipment. During the six week follow-up period (weeks 19 to 24), participants continued their independent, unsupervised Seniors Exercise Park use. Participants completed an exercise diary whenever they used the Seniors Exercise Park independently and returned the diary during the final assessment (at the week 24 appointment). During this six week independent practice period, participants were informed about occasional times when the researcher was at the Seniors Exercise Park if they needed consultation about any difficulties or issues they may have been having with independent Seniors Exercise Park use.

3.3.6 COVID-19 restrictions

The implementation of the assessments and intervention occurred during the COVID-19 pandemic. Measures were introduced to minimise the risk of COVID-19 infection among the participants during all exercise sessions. Participants practiced physical distancing, including keeping two metres away from each other and avoiding physical contact, such as hugs or handshaking during exercise sessions. The researcher and participants sanitised their hands before using the shared exercise equipment and before leaving the exercise park. The shared equipment was cleaned before, between, and after each exercise session.

Three lockdown periods (31 January 2021 to 5 February 2021, 24 April 2021 to 27 April 2021 and 29 June 2021 to 3 July 2021) occurred in Perth, Western Australia. Exercise sessions were cancelled during the lockdown periods and scheduled on another day outside the lockdown period. During the easing of the COVID-19 lockdown, participants wore facemasks during the exercise sessions conducted from 6 February 2021 to 13 February 2021, 28 April 2021 to 14 May 2021 and 3 July 2021 to 12 July 2021.

3.3.7 Outcome measures and measurement procedures

Participants completed standardised questionnaires and clinical assessments of balance, mobility, and strength during their baseline assessment, after 18 and 24 weeks, at an activity room at the retirement village (near the Seniors Exercise Park). Sections 3.3.9 and 3.3.10 describe the information and details for each outcome measure. Table 3.4 lists the outcome measures, purpose and indicates the direction required for improvement for all outcome measures. The PAR-Q+ and Abbreviated Mental Test were only used for screening purposes and are not shown in Table 3.4.

Table 3.4. Outcome measures collected

Outcome measures	**Measures**	**Improvement indicated by increase or decrease of scores / units**
EQ-5D-5L	Quality of life	Increase
Modified Falls Efficacy Scale	Fear of falling when performing tasks outdoors and indoors	Increase
PASE	Physical activity	Increase
UCLA Three-Item Loneliness Scale	Loneliness	Decrease
Self-Efficacy Scale for Exercise	Confidence to exercise when faced with barriers	Increase
WHO-5	Mental well-being	Increase
CBMS-Home	Balance and mobility	Increase
Four Square Step Test	Balance	Decrease
Fast Gait Speed Test	Walking ability	Increase
Five Times Sit to Stand	Lower body strength	Decrease

Note. EQ-5D-5L = European Quality of Life Scale-5D-5L; PASE = Physical Activity Scale for the Elderly; WHO-5 = Five Item World Health Organisation Well-Being Index; CBMS-Home = Community Balance and Mobility Scale-Home.

3.3.8 Screening: Standardised questionnaires

A copy of the questionnaires used are shown in Appendix 6.

3.3.8.1 Physical Activity Readiness Questionnaire for Everyone (PAR-Q+)

The PAR-Q+ was developed to minimise the barriers to physical activity participation for people with or without known chronic health conditions across all ages and genders (Bredin et al., 2013; Warburton et al., 2014). PAR-Q+ was used to screen for evidence of any risk factors before physical activity participation (Warburton et al., 2014). The questionnaire consists of seven questions and can be used by individuals of all ages (Bredin et al., 2013; Warburton et al., 2014). The test-retest reliability of the PAR-Q+ was high (r_s (144) = .99) when participants (mean age = 44.1 years, *SD* = 9.5) completed the questionnaire on repeated occasions administered three months apart (Warburton, Bredin, et al., 2011). In addition, the PAR-Q+ was able to discriminate between individuals with (sensitivity = 0.90, 95% CI [0.77, 0.96]) or without hypertension (specificity = 1.00, 95% CI [0.99, 1.00]) (Warburton, Bredin, et al., 2011).

During the initial screening over the phone, the participants were asked the first seven questions (e.g., presence of heart problems, other chronic medical conditions, joint, bone or soft tissue problems) in the PAR-Q+. If the participant answered ‘no’ to these questions, they could participate in the Seniors Exercise Park program. If the participant answered ‘yes’ to any of the seven questions, the participant was asked follow-up questions related to the specific chronic condition (e.g., arthritis). If the participants answered ‘yes’ to one or more follow-up questions, medical clearance from a general practitioner was required. The PAR-Q+ is valid for 12 months from the date of completion (Warburton, Jamnik, et al., 2011).

3.3.8.2 Abbreviated Mental Test

The Abbreviated Mental Test was used to assess cognitive performance (Hodkinson, 1972; Qureshi & Hodkinson, 1974). It is an abbreviated version consisting of 10 questions adapted from the Roth-Hopkins Test (Hodkinson, 1972; Qureshi & Hodkinson, 1974). All accurate answers were awarded one mark each, with a maximum score of 10. The Abbreviated Mental Test was highly correlated to the modified Tooting Bec Questionnaire (r (71) = .82 - .88) and Roth-Hopkins Test (r (71) = .87 - .96) (Qureshi & Hodkinson, 1974). The Abbreviated Mental Test demonstrated high internal consistency (Cronbach's alpha = .90) (Jitapunkul et al., 1991). A meta-analysis of Abbreviated Mental Test data demonstrated a specificity of 84% and sensitivity of 81%, with a cut-off score of less than seven points for the presence of dementia (Jackson et al., 2013). Practical limitations include one of the questions being culturally specific, and it requires the recognition of two people by the participant (Jackson et al., 2013).

The Abbreviated Mental Test was chosen as a screening tool for cognitive performance because it is brief and only takes approximately four minutes to complete. Two of the questions were modified, the 'year of the first world war' was adjusted to 'year of the second world war' and 'name of the present monarch' was changed to 'name of the prime minister' to match the current context of the country and participants (Peters et al., 2021; Piotrowicz et al., 2019). During the initial screening over the phone, participants answered nine questions on the Abbreviated Mental Test, and the final question, that is, the recognition of two individuals was scored during the day of their baseline assessment.

3.3.9 Efficacy testing: Standardised questionnaires

A copy of the questionnaires used for efficacy testing are shown in Appendix 7.

3.3.9.1 European Quality of Life Scale-5D-5L (EQ-5D-5L)

The EQ-5D-5L measured health-related quality of life (Devlin & Krabbe, 2013). It has been used with individuals who have many different health conditions (e.g., diabetes, cancer, musculoskeletal problems, arthritis, stroke, and depression) (Feng et al., 2021; Janssen et al., 2013; Kang et al., 2021) and has been used across the world (Janssen et al., 2013).

The EQ-5D-5L is a health status questionnaire that consists of a descriptive section and a visual analogue scale (Feng et al., 2021). Five dimensions in the descriptive section are self-care, mobility, pain or discomfort, usual activities, and anxiety or depression (Janssen et al., 2013). Each dimension consists of five possible responses: no problems, slight problems, moderate problems, severe problems, and extreme problems or unable to complete the dimension (Janssen et al., 2013). Each response completed within each dimension corresponds to a single digit number, and when combined, this results in a five-digit number (i.e., an index value) converted to a utility weight. In a recent systematic review, the dimensions and index values demonstrated moderate to strong correlations with pain, physical performance measures, activities of daily living, and measures of emotional and mental health among people aged 18 years or older (Feng et al., 2021). The visual analogue scale is a separate section of the EQ-5D-5L and is a vertical line where participants self-rate their health state ranging from zero (worst health) to 100 (best health) (Janssen et al., 2013).

This study’s scoring adopted the algorithm developed for the Australian population (Norman et al., 2013). The algorithm used a discrete choice experiment technique to derive the utility values (Norman et al., 2013). The utility values derived from the Australian algorithm ranged from -0.676 (poor health) to one (excellent health) (Norman et al., 2013).

During the day of each assessment, the participants self-selected the response that best matched their current health state. The utility value for each participant was calculated with STATA version 17.0, 2021 (StataCorp., 2021) using the scoring algorithm provided by Norman et al. (2013). This study registered with the European Quality of Life Research Foundation for using EQ-5D-5L.

3.3.9.2 Modified Falls Efficacy Scale

The Modified Falls Efficacy Scale measured falls efficacy in performing a range of indoors and outdoors activities of daily living (Hill, Schwarz, et al., 1996). It is a 14-item questionnaire whereby the participants rated how confident they were when performing the activities without falling (Hill, Schwarz, et al., 1996). The scale for each item ranges from "zero" (not confident at all) to "10" (completely confident) and is depicted on a visual analogue scale. The final score consists of an average of the 14 items, with a higher score representing higher falls efficacy. The average score on Modified Falls Efficacy Scale is 9.8 (*SD* = 0.3) for healthy community-dwelling older adults (mean age 74.0 years, *SD* = 4.0) (Hill, Schwarz, et al., 1996) and 9.8 (range = 9.2 - 10) for community-dwelling healthy women (mean age 74.1 years, *SD* = 4.0) (Hill et al., 1999).

The test-retest reliability ($ICC_{3,1}$ = 0.95) and internal consistency were high (Cronbach's alpha = .95) in a group of older people who were fallers and non-fallers (Hill, Schwarz, et al., 1996). Factor analysis revealed two factors that accounted for

75% of the total variance and were labelled as “indoor type activity” and “outdoor type activity” (Hill, Schwarz, et al., 1996).

The Modified Falls Efficacy Scale was determined as one of the measures with acceptable reliability when reviewed with other fall efficacy measures in a systematic review (Jørstad et al., 2005). In a recent systematic review, the Modified Falls Efficacy Scale was reported to be comprehensive and relevant to the measurement of falls efficacy when reviewed for content validity (Soh et al., 2021). The Modified Falls Efficacy Scale is also unidimensional, measuring either balance confidence or falls efficacy, and met the criterion for structural validity (Soh et al., 2021).

3.3.9.3 Physical Activity Scale for the Elderly (PASE)

The PASE measures the physical activity of older adults (i.e., aged 65 years and older) (Washburn et al., 1993). The survey gathers information on the current levels of participation in the household (e.g., light housework), occupation (e.g., volunteer work), and leisure activity (e.g., light intensity physical activity) of the participants over the last seven days (Washburn et al., 1993). Participants’ responses to the items are weighted and tabulated to determine the total scores ranging from zero to 400. The higher the PASE score, the more physically active a participant is (New England Research Institutes, 1991). HealthCore Inc granted permission to use the PASE for this research.

The PASE was determined to have acceptable validity to other physical activity surveys, including the Community Healthy Activities Model Program for Seniors Questionnaire and Yale Physical Activity Survey (Harada et al., 2001). Previous studies have validated the PASE against physical performance, physiological measures, and physical activity surveys. The PASE was significantly associated with the Six Minute Walk Test (r (86) = .46, $p < .01$) and the Short Physical Performance Battery (r (86) = .57, $p < .01$) (Harada et al., 2001), Actigraph mean steps per minute (r (55) = .43, $p < .01$) (Dinger et al., 2004), systolic blood pressure (r (101) = - .30, $p < .05$), and peak oxygen uptake (r (101) = .26, $p < .05$) (Washburn et al., 1999). PASE was also moderately correlated with Yale Physical Activity Survey (r (86) = .61, $p < .01$) and the Community Healthy Activities Model Program for Seniors Questionnaire (r (86) = .58, $p < .01$) (Harada et al., 2001). Men scored higher on the PASE than women (Loland, 2002; Washburn et al., 1999). Test-retest reliability of the PASE was high (ICC = 0.91, 95% CI [0.83, 0.94]) when administered on two occasions, three days apart with older adults (mean age = 75.7 years, *SD* = 7.9) living in the community (Dinger et al., 2004). The internal consistency of the PASE was good (Cronbach's alpha = .73) (Loland, 2002).

A systematic review highlighted that the PASE and another physical activity questionnaire (Physical Activity and Sedentary Behaviour Questionnaire) demonstrated adequate construct validity and reliability (Sattler et al., 2020). The authors recommended that the PASE should be used for measuring total physical activity in older adults (Sattler et al., 2020).

3.3.9.4 UCLA Three-Item Loneliness Scale

The UCLA Three-Item Loneliness Scale was adapted from the Revised UCLA Loneliness Scale (Hughes et al., 2004). The survey evaluated loneliness by asking how often participants felt isolated, left out, or lacked companionship (Hughes et al., 2004). The response for each item ranged from "hardly ever", "some of the time", or "often." The total scores for the UCLA Three-Item Loneliness Scale range from three to nine, with higher scores representing a higher degree of loneliness (Hughes et al., 2004).

The UCLA Three-Item Loneliness Scale was a valid and reliable measure of loneliness in a population-based study (Hughes et al., 2004) and has been used in large-scale research, such as the Health and Retirement Study (Luo et al., 2012; Perissinotto et al., 2012) and the English Longitudinal Study of Ageing (Pikhartova et al., 2016). The UCLA Three-Item Loneliness Scale's internal consistency was satisfactory (Cronbach's alpha = .72). The UCLA Three-Item Loneliness Scale was correlated significantly with the Revised UCLA Loneliness Scale (r (228) = .82, $p \leq .001$), short form of the Centre for Epidemiologic Studies Depression Scale (CES-D) (r (228) = .49, $p \leq .01$), and the Four-Item Perceived Stress Scale (r (228) = .40, $p \leq .01$) (Hughes et al., 2004).

3.3.9.5 Self-Efficacy for Exercise Scale

The Self-Efficacy for Exercise Scale evaluates the barriers to exercise self-efficacy in older adults (Resnick & Jenkins, 2000). It is a nine-item scale measuring the degree of confidence to exercise when faced with barriers such as pain, boredom, exercising alone, or poor weather. Each item score ranges from "zero = not confident" to "10 = very confident." The total score is a summation of the scores of the nine items and ranges from "zero" to "90", with higher scores indicating higher self-efficacy for exercise (Resnick & Jenkins, 2000).

The Self-Efficacy for Exercise Scale was validated among people living in continuing care retirement communities (mean age = 85.0 years, *SD* = 6.2) (Resnick & Jenkins, 2000). The internal consistency was good (Cronbach's alpha = .92) (Resnick & Jenkins, 2000). The physical and mental health scores on the 12-item Short-Form Health (SF-12) survey predicted self-efficacy expectations as evaluated by the Self-Efficacy for Exercise Scale (Resnick & Jenkins, 2000). In addition, self-efficacy expectations measured by the Self-Efficacy for Exercise Scale predicted exercise activity (Resnick & Jenkins, 2000). Factors such as mental and physical health, gender, and age were found to influence self-efficacy expectations and may influence behaviour to exercise (Resnick et al., 2000).

3.3.9.6 Five-Item World Health Organisation Well-Being Index (WHO-5)

The WHO-5 measures the subjective well-being of a person over the past two weeks. WHO-5 contains five positively phrased items (Topp et al., 2015). Each item's score ranges from zero (none of the time) to five (all the time) (Topp et al., 2015). The raw total score ranges from zero (absent well-being) to 25 (maximum well-being) and is multiplied by four to obtain a percentage (Topp et al., 2015).

A systematic review demonstrated that the WHO-5 was specific and sensitive to screen for depression, can be applied across the population (e.g., older adults, children), and had high clinimetric validity (Topp et al., 2015). WHO-5 demonstrated good internal consistency among older adults living in the community (Bonsignore et al., 2001) and nursing homes (Allgaier et al., 2013) and was also able to detect depression (Allgaier et al., 2013; Bonsignore et al., 2001). A cut off score of ≤ 12 had a high sensitivity (0.92, 95% CI [0.75, 0.99]) and acceptable specificity (0.79, 95% CI [0.67, 0.88]) to detect depression (Allgaier et al., 2013).

3.3.10 Efficacy testing: Physical performance measures

The CBMS-Home, the Functional Reach Test, and the Step Test were described in the previous section (3.2.6). This current section will focus on describing the remaining physical performance outcome measures used in this study (Four Square Step Test, Five Times Sit to Stand Test, and Four Metre Fast Gait Speed Test).

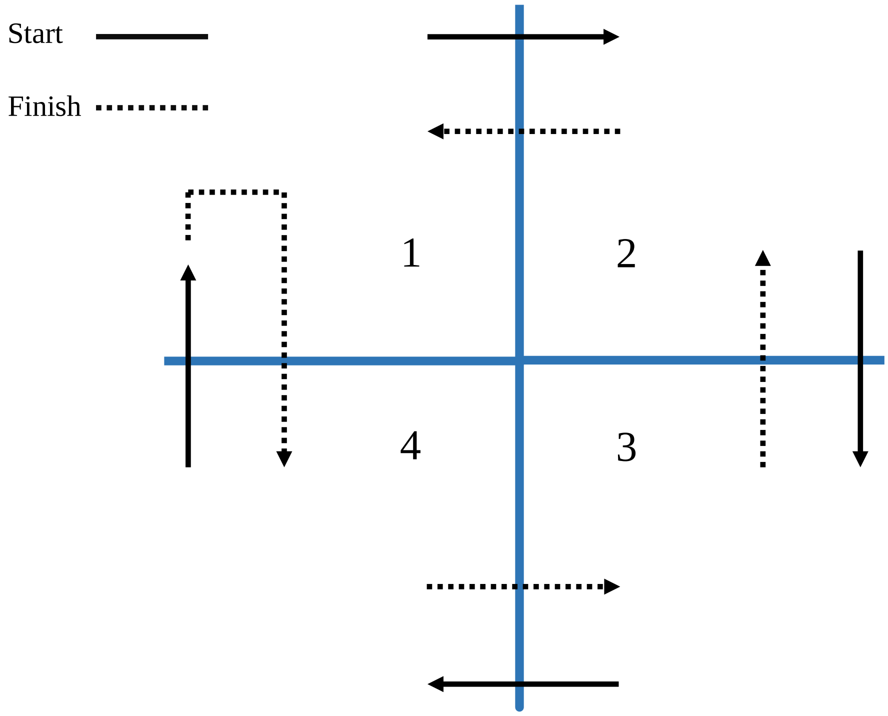
All participants completed the outcome measures in the same order of assessment. Each task was demonstrated first to ensure the participant understood how to perform the test. If the individual did not understand the task, instructions were repeated, and a second trial was conducted. Participants completed all of the tests without using a walking aid. Participants wore a safety gait belt secured around their waist so that the researcher could stabilise the participants if they experienced any loss of balance while undertaking the tasks.

3.3.10.1 Four Square Step Test

The Four Square Step Test evaluated the ability of the person to step rapidly in different directions (i.e., forward, sideways, and backward) over a low obstacle (Dite & Temple, 2002). The Four Square Step Test consists of four single-point pipes/sticks (1.3 cm diameter) arranged in a cross pattern placed on the floor (See Figure 3.5).

During the performance of the Four Square Step Test, the participants wore their own shoes. The time the participants took to step over the pipes clockwise to return to the starting position, and then anticlockwise back to the starting position, was recorded. The timing started when the participant's feet first contacted the first quadrant and ended when both feet returned to the starting quadrant. Before the testing, the researcher demonstrated the test, and the participant did one practice trial. Instructions to the participant were: "Try to complete the sequence as fast as possible without touching the pipes. Both feet must contact the floor in each square. If possible, face forward during the entire sequence" (Dite & Temple, 2002, p. 1568). The participant repeated the test if one of the feet touched the pipe, performed the sequence incorrectly, or lost his/her balance (Dite & Temple, 2002).

Figure 3.5. Set up for the Four Square Step Test



Note. Adapted from Dite, W., & Temple, V. A. (2002). A clinical test of stepping and change of direction to identify multiple falling older adults. *Archives of Physical Medicine Rehabilitation, 83*(11), 1566-1571. https://doi.org/10.1053/apmr.2002.35469.

The Four Square Step Test is a valid and reliable measure for fall screening and balance assessment in older adults (Dite & Temple, 2002) and adults with different health conditions (e.g., osteoarthritis, multiple sclerosis, Huntington's disease, Parkinson's disease) (Moore & Barker, 2017). Eighty-one community-dwelling older adults were involved to determine the validity of the Four Square Step Test in comparison with other physical performance measures (Dite & Temple, 2002). The Four Square Step Test time correlated significantly with balance (Step Test and Functional Reach Test) and mobility (Timed Up and Go Test) (Dite & Temple, 2002). High test-retest reliability (ICC = 0.98) and inter-rater reliability (ICC = 0.99) were also found for the Four Square Step Test (Dite & Temple, 2002). The mean duration for a sample of active older adults (mean age = 74.1 years, *SD* = 6.1) to complete the Four Square Step

Test was 8.7 seconds, 95% CI [7.36, 10.01] (Dite & Temple, 2002). In another study of community-dwelling older adults, the results demonstrated that the duration taken to complete the Four Square Step Test increased with increasing age (Choudhary, 2020).

Older adults who took longer than 15 seconds to complete the Four Square Step Test are more likely to be multiple fallers (Cleary & Skornyakov, 2017; Dite & Temple, 2002). In addition, the 15 second cut-off score accurately classified 21.2% of older adults as fallers when followed up over the subsequent 12 months after the baseline test (Cleary & Skornyakov, 2017).

3.3.10.2 Five Times Sit to Stand Test

The Five Times Sit to Stand Test measures lower body balance and strength (Bohannon, 1995; Lord et al., 2002). Participants folded their arms across their chest and stood up from a chair five times as fast as they could safely without using their hands to assist them. The chair seat height was 43cm. The performance of the test was timed using a stopwatch. The researcher demonstrated the test first, and the participant did a practice trial. The instructions provided to the participants were, “Stand up and sit down five times as quickly as you can when I say ‘go’. Ready, go.” The researcher counted out each stand so that the participants knew the number they had completed. The timer (i.e., handheld stopwatch) was stopped when the participant completed the fifth stand up. The duration to complete the test and whether the participant used his/her hands to stand up were recorded.

The Five Times Sit to Stand Test has been validated in a number of studies among older adults living in the community (Bohannon et al., 2010; Schaubert & Bohannon, 2005; Whitney et al., 2005; Yee et al., 2021). The Five Times Sit to Stand Test was moderately correlated with the Dynamic Gait Index (r (80) = - .68, $p < .001$) and the Activities and Balance Confidence Scale (r (80) = - .58, $p < .001$) (Whitney et al., 2005), Timed Up and Go Test (r (886) = .65, $p < .01$), Six Minute Walk Test (r (886) = - .53, $p < .01$) and gait speed (r (886) = - .53, $p < .01$) (Yee et al., 2021). The test-retest reliability findings of the Five Times Sit to Stand Test were high, with an ICC = 0.81 when measured repeatedly in healthy older adults (Schaubert & Bohannon, 2005) and $ICC_{3,1}$ = 0.89, 95% CI [0.79, 0.95] in older adults living in the community, including those with mobility limitations (Tiedemann et al., 2008). The mean time taken for healthy older adults to complete the Five Times Sit to Stand Test according to age range was: 60-69 years = 7.8 seconds (*SD* = 2.4), 70-79 years = 9.3 seconds (*SD* = 2.1), and 80-85 years = 10.8 seconds (*SD* = 2.6) (Bohannon et al., 2010).

The Five Times Sit to Stand Test was also used as a screening test for the risk of falls among older adults (Buatois et al., 2008). Studies reported that older adults who experienced falls and took longer than 15 seconds to complete the Five Times Sit to Stand Test were at an increased risk of recurrent falls (Buatois et al., 2008; Buatois et al., 2010). Older adults with balance dysfunction (mean duration Five Times Sit to Stand Test = 16.4 seconds, *SD* = 4.4) took longer to complete the Five Times Sit to Stand Test compared to those without balance dysfunction (mean duration Five Times Sit to Stand Test = 13.4 seconds, *SD* = 2.8) (Whitney et al., 2005).

3.3.10.3 Four Metre Fast Gait Speed Test

Gait speed is an objective and valid measure of functional mobility in various research and clinical settings (Barthuly et al., 2012; Karpman et al., 2014; Van de Vyver et al., 2020). The timing for gait speed can include a dynamic start (after a period of acceleration) or a static start (when walking starts) (Bohannon & Wang, 2019). The typical distances reported for timed gait tests were four, six, or 10 metres (Graham, Ostir, Fisher, et al., 2008), but four metres has been increasingly used to measure gait speed (Bohannon & Wang, 2019). Previous reviews have reported no significant difference in gait speed with the type of start (dynamic or static) used during a gait speed test (Graham, Ostir, Kuo, et al., 2008; Peel et al., 2012). In addition, gait speed was not influenced by the distance of the gait test (Peel et al., 2012). Therefore, for this study, the fast gait speed test used a shorter walkway (four metres) and a static start based on the findings above and due to space limitations at the testing venue.

During the test, the four metre walkway included a starting line and a finish line at four metres (Bohannon & Wang, 2019). The lines were marked by masking tape applied to the floor. Participants stood with their toes behind the starting line and were instructed to walk as quick as possible and to continue walking past the finish line (Bohannon & Wang, 2019). Participants were given the command "Ready, three, two, one, go." The timing of the test started when the first foot touched the starting line and was stopped when the first foot crossed the finish line (Bohannon & Wang, 2019). The time for the test (in seconds) was converted to speed (metres per second). The timing was measured using a handheld stopwatch.

The test-retest reliability of fast gait speed on two repeated trials within the same test session was high ($ICC_{3,1}$ = 0.93, 95% CI [0.81, 0.98]) (Goldberg & Schepens, 2011) and moderate ($ICC_{3,1}$ = 0.46, 95% CI [0.33, 0.57]) when the two repeated trials were tested on two different occasions (mean days apart = 8.6 days) (Bohannon & Wang, 2019). Fast gait speed was correlated significantly with lower body strength (r (229) = .29 - .50, $p < .01$) (Bohannon, 1997), and knee extension strength for men (r (110) = .38, $p < .01$) and women (r (206) = .45, $p < .01$) (Hayashida et al., 2014). There appears to be a significant relationship between fast gait speed and health, that is, slower gait speed is associated with poorer self-rated health among older adults (age range 65-84 years) (Jylhä et al., 2001).

Community-dwelling older men tended to walk faster than older women, and younger individuals (60-69 years) walked faster compared to older individuals (70-79 years) (Bohannon & Wang, 2019; Tibaek et al., 2015). The mean fast gait speed for older men (mean age = 73.3 years, *SD* = 2.5) was 1.54 metres/second, *SD* = 0.37 and older women (mean age = 72.9 years, *SD* = 2.3) was 1.36 metres/second, *SD* = 0.32 during the Four Metre Fast Gait Speed Test with a static start (Bohannon & Wang, 2019). The low value of the standard error of measurement (SEM), SEM = 0.05 metres/second, suggested that fast gait speed evaluated over four metres demonstrated excellent repeatability over several trials (Goldberg & Schepens, 2011). In addition, the index of real change in fast gait speed, known as minimal detectable change (MDC), was low, MDC_{95} = 0.14 metres/seconds, suggesting that a Four Metre Fast Gait Speed Test may be sensitive and responsive to change (Goldberg & Schepens, 2011).

3.3.11 Practicality: Adherence to the Seniors Exercise Park intervention

Adherence is defined as the extent to which an individual followed the suggestions of a health care professional (Rivera-Torres et al., 2019; World Health Organisation, 2003); for example, older adults with mild balance dysfunction following the exercise recommendations of the physiotherapist delivering the Seniors Exercise Park program. Measures used to determine adherence in the literature included attendance adherence and the proportion of days that exercise was completed independently (Hawley-Hague et al., 2016; Picorelli et al., 2014; Rivera-Torres et al., 2019). Measurement of adherence to the Seniors Exercise Park intervention consisted of attendance during supervised and independent Seniors Exercise Park sessions. Attendance adherence was measured by the percentage of supervised classes attended by the participants (i.e., [the number of sessions attended ÷ number of sessions offered in 18 weeks] × 100). Adherence to independent practice was measured by the proportion of days that exercise was performed at the Seniors Exercise Park independently (i.e., week one to 18 [number of days the participant exercised independently ÷ 14 independent sessions requested x 100] and week 19 to 24 [number of days the participant exercised independently ÷ 12 independent sessions requested x 100]. If the participants exercised beyond the recommended number of independent sessions, the actual percentage of a participant's adherence is reported (e.g., 14 ÷ 12 x 100 = 116.7 %). If the participant was not able to exercise at the Seniors Exercise Park because of adhering to lockdown regulations, the total number of independent sessions was adjusted accordingly (Levinger, Dunn, et al., 2021). Participants were required to complete a diary on each occasion they visited the park, and these diaries were collected after weeks 18 and 24 (See Appendix 8 for a copy of the exercise diary).

3.3.12 Data analysis

The data were analysed using STATA version 17.0, 2021 (StataCorp., 2021). Further information on data analysis for this study is described in Chapter 6.

3.4 Experiences of older adults with mild balance dysfunction who participated in a supervised Seniors Exercise Park program progressing to independent practice

3.4.1 Study design

This study was part of the quasi-experimental one-group pre-post intervention study (Chapter 6). An interpretive phenomenological approach using face-to-face interviews conducted after weeks 18 and 24 was undertaken. This approach enabled the researcher to gain an in-depth understanding of participants' lived experiences within their present environment (Lopez & Willis, 2004; Neubauer et al., 2019).-This study aimed to understand the experiences of the older participants, as well as the facilitators and barriers to them undertaking supervised and independent exercise at the Seniors Exercise Park.

3.4.2 Study population and sample

Participants who completed the 18 week Seniors Exercise Park supervised intervention program were invited to participate in the interview. Interviews were repeated for those continuing their Seniors Exercise Park practice independently through to 24 weeks.

3.4.3 Study setting

The interviews were conducted face-to-face with the participant in a room at the retirement village where the other measurement outcomes were also undertaken. This was located next to the Senior Exercise Park.

3.4.4 Data collection

After the participants completed the standardised questionnaires and physical performance assessments at the 18 and 24 week assessments, they were interviewed immediately. Participant's consent was obtained using the same consent form used for the quasi-experimental one-group pre-post intervention study (Chapter 6). Participants were also briefed about the purpose of the interviews and informed that the interviews were audio-recorded. The researcher also made written notes during each interview. An interview guide was used to provide some guidance for the interview, but it was not strictly followed (Appendix 9). Where the participant's answers required further questioning to gather additional data, the participant was asked questions not included in the guide. The guide was reviewed by researchers with qualitative experience, and the interviewer was provided with training. The interview was based on participants' perceptions of the supervised Seniors Exercise Park program, their experience of independent exercise, and factors influencing their participation. Interviews were conducted until no new information was obtained (i.e., data saturation) (Johnson et al., 2020).

3.4.5 Data analysis

Each interview was transcribed verbatim by an independent transcriber and then read several times by the researcher. The data were coded by two independent researchers (i.e., PhD student and supervisor) and managed using Excel software. The analysis process consisted of highlighting relevant words or phrases, coding and grouping the data to form themes. Further information on data analysis is described in Chapter 7, reporting the qualitative results of the Seniors Exercise Park program.

3.5 Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic

3.5.1 Study design

This exploratory qualitative study used a phenomenological approach. A phenomenological approach focuses on the lived experiences of the individual, including awareness of the lifeworld, the presence of the person in the world, interaction with others, and the meaning of the lived experiences (Sundler et al., 2019). The objective of this study was to explore the lived experiences of older retirement village residents and how COVID-19 had affected their physical activity participation; hence a phenomenological approach was appropriate.

3.5.2 Study population and sample

Participants were recruited from two retirement villages in Perth, Western Australia, who had participated in previous research and gave consent to be contacted for participation in future research. Information on the inclusion criteria is described in Chapter 8.

3.5.3 Study setting

All interviews were conducted over the phone due to the Western Australian government's COVID-19 restrictions at the time of data collection, and the conversations were audio-recorded. Telephone interviews were a reliable and valid method suggested for qualitative interviews during COVID-19 restrictions (Saarijärvi & Bratt, 2021). Although the researcher was unable to see the participant for body language cues for additional information, social cues such as intonation and voice were still available (Opdenakker, 2006). In addition, telephone interviews encouraged the participants to talk freely and openly and avoided potential stereotyping of the participants based on their visual behaviour and traits by the researcher (Vogl, 2013).

3.5.4 Recruitment and data collection

The researcher called the participants by phone, and if they were interested in participating and met the inclusion criteria, they received further information about the research through e-mail (See Appendix 10). If participants agreed to participate in the research, they sent back a signed consent statement. An appointment for an interview was arranged and conducted with the participant on average 3.7 days (SD = 2.8) after receiving the signed consent statement. Before the start of the interview, participants were informed about anonymity and confidentiality procedures. An additional verbal consent to the interview was also obtained. At the commencement of the interview, demographic data were collected.

3.5.5 Data analysis

Data analysis was described in the published paper reporting the results of this study (Chapter 8).

3.6 Establishing rigour for qualitative research (Chapters 7 and 8)

When undertaking qualitative research, it is important to establish rigour so that the data are of adequate quality (Morse, 2015) and the findings may be applied to other people, groups, situations or settings of a similar nature (Liamputtong, 2013; Quick & Hall, 2015). Four strategies to achieve rigour in the two qualitative studies (sections 3.3 and 3.5) included: extended engagement with participants; a rich and thick description of the data; two researchers analysing the data; and minimising researcher bias (Morse, 2015). These are described in more detail below, in the context of both qualitative studies in this thesis.

- **Extended engagement with participants**

Extended engagement with participants increases the richness and quality of the data, and this can be accomplished by building trust when the researcher spends more time engaging with the participants (Morse, 2015; Quick & Hall, 2015). This was achieved by communicating well and often with the participants, listening, and addressing participants' questions and concerns during data collection and projecting an image of competence and calm during interactions with the participants.

- **Rich description**

Sufficient sample size is critical to gathering rich and in-depth data (Morse, 2015). Semi-structured interviews continued until no new information was obtained, known as data saturation (Hennink et al., 2017; Moser & Korstjens, 2018). Data saturation can be classified as code saturation or meaning saturation. Code saturation is described as the point when the codebook stabilises, and no further information is identified and has been reported to occur with as few as nine interviews (Hennink et al., 2017). However, the data obtained may not be sufficient to understand the depth of the data (Hennink et al., 2017). Meaning saturation was described as the point when the issues were fully understood, and no further information could be identified from the data (Hennink et al., 2017) and required interpretation (Braun & Clarke, 2021). For this thesis, interviews were conducted until meaning saturation occurred.

In addition, rich description also includes providing description of the participants, detailed information about the research settings and methods of the research, which are important to help readers determine whether the study findings may be applied to other individuals, groups, or settings of a similar nature (Liamputtong, 2013), and this information is described in Chapters 7 and 8.

- **Data analysis**

Two independent researchers analysed the data to ensure the reliability of the data (Morse, 2015). Then, the two researchers collated and compared their findings before sending them to a third researcher for review.

- **Minimise researcher bias**

All the data obtained were continually read, and transcripts were evaluated multiple times and analysed to minimise researcher bias. In addition, the interview questions were asked in a certain order, that is, by asking general questions first before progressing to sensitive or specific questions (Shah, 2019). Leading questions were avoided to avoid favouring a particular answer (Shah, 2019). For this thesis, two experienced qualitative researchers read the interview guide questions before the interviews were conducted.

3.7 Ethics approval

For all the studies in this thesis, participants received detailed information about the research and gave written informed consent for each study before any data collection (See Appendix 11 for participant consent forms). Each study received ethics approval from Curtin University Human Research Ethics Committee (See Appendix 12 for approval letters).

3.8 Data storage

All data were entered into an electronic database. These data were identified by research identification numbers and stored in a password-protected folder accessible only by the researchers. Hard copies of the data were filed and placed in a locked filing cabinet at Curtin University, Curtin School of Allied Health, Faculty of Health Sciences. The data will remain at Curtin University for seven years. All the data will be destroyed following Curtin University’s guidelines when the required deadline has passed.

Chapter 4 : Effectiveness of outdoor exercise parks on health outcomes in older adults − A mixed-methods systematic review and meta-analysis

Chapter outline

This chapter presents the findings of the systematic review and meta-analysis conducted to synthesise the literature on outdoor exercise park use and its effects on the health of older adults.

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Ng, Y.L., Hill, K.D., Levinger, P., & Burton, E. (2020). Effectiveness of Outdoor Exercise Parks on Health Outcomes in Older Adults—A Mixed-Methods Systematic Review and Meta-Analysis. *Journal of Aging and Physical Activity*, 29(4), 695-707. https://doi.org/10.1123/japa.2020-0031.

This study has been presented at the following conference as a poster presentation:

Ng, Y.L., Hill, K. D., Levinger, P., & Burton, E. (May 7, 2021). Effectiveness of Outdoor Exercise Equipment in Older People: A Systematic Review and Meta-analysis. Exercise and Sports Science Australia, Research to Practice 2021 Virtual Conference. https://az659834.vo.msecnd.net/eventsairaueprod/production-essa-public/e2c79bdda816461a989dd95c9036e2f2

4.1 Abstract

The objective of this systematic review was to examine the effectiveness of outdoor exercise park equipment on physical activity levels, physical function, psychosocial outcomes, and quality of life of older people living in the community and evaluate the evidence of older people's use of outdoor exercise park equipment. A search strategy was conducted from seven databases. Nine articles met the inclusion criteria. The study quality results were varied. Meta-analyses were undertaken for two physical performance tests: 30 second chair stand test, and single leg stance. The meta-analysis result was not statistically significant. It was not possible to conclude whether exercise parks were effective at improving levels of physical activity. The review shows that older people value the benefits of health and social interaction from the use of exercise parks. Findings should be interpreted with caution due to the small sample sizes and the limited number of studies.

4.2 Introduction

The global population of older people is predicted to triple from 524 million in 2010 to 1.5 billion in 2050 (World Health Organization, 2011). Increasing age is associated with an increased risk of morbidity and development of chronic disease. Regular participation in physical activity can reduce the risk of chronic disease (González et al., 2017; Guthold et al., 2018), slow physiological aging changes, maintain bone health, improve psychological and mental well-being (Bauman et al., 2016; Singh, 2002) and decrease the risk of mortality, and loss of functional independence (Bauman et al., 2016; Paterson & Warburton, 2010). However, studies report that only 20% to 60% of older people engage in adequate levels of physical activity and their participation declines with increasing age (Sun et al., 2013). Novel approaches are required to improve sustained physical activity participation by older people.

Community parks provide people with the opportunity to participate in physical and leisure activities and can facilitate social interactions (Bedimo-Rung et al., 2005). Observational studies have shown that older people visit parks to perform a variety of activities that include different intensity levels (Cohen et al., 2007; Moore et al., 2019; Veitch et al., 2015) and for the social aspects (Cohen et al., 2007). Performing physical activity outdoors may positively influence the health of park users (Dadvand et al., 2016) by reducing stress and perceptions of exertion, improving self-esteem and mood (Gladwell et al., 2013) and improving socialization (Furber et al., 2014).

Outdoor exercise equipment installed strategically in parks is an example of a potentially sustainable health approach that enhances public access to physical and leisure activity areas. Installation of outdoor exercise equipment can increase park visits (Furber et al., 2014). These exercise equipment may be spread along a trail or grouped together and are usually located outdoors in parks or public spaces (City of

Sydney, 2020). Various terminologies are used to describe exercise equipment installed in parks including “outdoor fitness equipment” (Chow, 2013), “golden age gym” (Salin et al., 2014), “equipment at a public park” (Leiros-Rodríguez & García-Soidan, 2014), “seniors playground” (Bettencourt & Neves, 2016), “exercise park” (Sales et al., 2017), “open gyms” (Mora, 2012), “seniors exercise park” (Sales et al., 2018), “outdoor exercise equipment” (Kim et al., 2018), “outdoor gyms” (Lee et al., 2018) , “stretch station circuit” (Sibson et al., 2018) and “fitness zones” (Sami et al., 2018). The terminology “exercise parks” will be used to describe outdoor exercise equipment installed in community parks throughout this article.

Exercise parks have been installed widely, for example in the United States of America (Cohen, 2010), Australia (Furber et al., 2014; Scott et al., 2014), Brazil (Mathias et al., 2018), Colombia (Ramírez, 2017), China (Traverso, 2019) and Taiwan (Chow et al., 2017) because of the capacity to provide an alternative physical activity option to people who like to exercise outdoors. Some of these exercise parks are designed specifically for older people such as in Australia (Levinger et al., 2018), China, Berlin, London and Toronto (Traverso, 2019) whilst the majority are built for people aged 13 years and above of all fitness levels (Cohen et al., 2012). These exercise parks are free of charge and provide users, including older people, the convenience of performing physical activity at any time of the day.

Physical activity preferences are different across the lifespan (Gavin et al., 2015). Many older people prefer being physically active in outdoor public spaces (Alley et al., 2018) and the most common physical activity undertaken by older people is walking (Amireault et al., 2019; Merom, Pye, et al., 2012). Although there are health benefits associated with walking (Lee & Buchner, 2008), it is a single modality of physical activity. Multi-modal physical activity options are important to achieve health benefits across different domains (i.e., balance, strength, and cardiovascular fitness) and are recommended by national and global physical activity guidelines for older people (Sims et al., 2010; World Health Organisation, 2010). Outdoor public spaces, such as exercise parks can offer multi-modal physical activity options and provide an opportunity for older people to be physically active at their own pace.

Previous systematic reviews have been conducted investigating outdoor exercise parks. Lee et al. (2018) found that the pursuit of good health and the opportunity for social interaction were the main reasons for using exercise parks. Jansson et al. (2019) revealed that exercise parks may improve fitness, physical activity and, other health outcomes. Both reviews provided information about the synthesis of research on the user characteristics of exercise parks and their effects on health across all age groups. However, the use and effects of exercise parks on health outcomes specifically amongst older people were not addressed. Therefore, this systematic review aims to (i) examine the effects of exercise parks on physical activity, physical function, psychosocial outcomes, and quality of life of older people living in the community and (ii) evaluate the evidence of older people's use of exercise parks (i.e., use is defined as the act of using the exercise parks).

4.3 Methods

Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) is a comprehensive guideline which consists of a minimum set of items for reporting a systematic review and meta-analysis (Moher et al., 2009). This systematic review was conducted following the PRISMA guidelines (Moher et al., 2009).

4.3.1 Inclusion criteria

Both quantitative and qualitative studies were included in the review if they met all of the following PICO (i.e., P: Population, I: Intervention, C: Comparison, O: Outcome(s)) and setting inclusion criteria:

Population: people aged 60 years and over or samples with at least 50% of participants aged 60 years and over, where younger age groups were included but data was reported separately for those aged 60 years or older.

Intervention: interventions delivered using exercise parks (i.e., exercise equipment installed in outdoor community parks) which target key components to benefit aging (e.g., balance and/or strength and/or endurance and/or flexibility and/or mobility) with the aim of increasing physical performance.

Comparison group: applicable for randomized controlled trials and non-randomized controlled trials only. No restrictions were imposed on the comparison group.

Outcomes: primary outcomes included physical activity levels using either objective (for example pedometer, accelerometer, and fitness trackers) or subjective self-report (for example Community Healthy Activities Model Program for Seniors (CHAMPS) physical activity questionnaire, Physical Activity Scale for the Elderly (PASE) questionnaire) and/or physical function health outcomes (for example balance, strength, mobility, and endurance). Other outcomes may include subjective self-report of quality of life and/or psychosocial outcomes (e.g., social support, mental well-being).

Setting: living independently in the community.

4.3.2 Exclusion criteria

Studies of older people who were residing in residential aged care or hospital at the time of the study were excluded from the review. Posters, dissertations, conference abstracts, proceedings and non-peer reviewed material (gray literature) were also excluded.

4.3.3 Data sources

Seven electronic databases (PsycINFO, MEDLINE, CINAHL Plus with full text, Scopus, EMBASE, Cochrane library, and SPORTDiscus) were searched for articles from inception to 6 January 2020. Only journal articles published in English that involved human participation were included. The reference lists of the included articles were searched for additional references.

4.3.4 Search strategy

Keywords were used to identify eligible articles for all databases using titles and/or abstracts. Table 4.1 is an example of the search strategy used in MEDLINE. The search was modified to accommodate the language and syntax used by each database.

Table 4.1. Search strategy using MEDLINE

1.	old* or senior* or elder* or age* or aging or geriatric* or “senior citizen*” or “older people” or “older person*” or gerontology or “older adult*” or “old age” or “older participant*” or “healthy age*” or “aged, 80 or over” or “healthy aging”
2.	“exercis* park” or “outdoor exercis*” or “outdoor exercise park*” or “outdoor exercise equipment” or “outdoor recreation* area*” or “fitness zone*” or “outdoor* gym*” or “senior* exercise park*” or “outdoor fitness” or “outdoor fitness equipment” or “outdoor* park*” or “outdoor recreation* facilit*” or “public fitness facilit*” or “recreation* park*” or “communit* park*” or “stretch station circuit*” or “active park*” or “open gym*” or “geriatric park*” or “golden age gym*” or “elderly fitness corner*” or “third age fitness cent*” or “senior* playground” or “age* friendly exercise park*” or “open air gym*” or “public fitness equipment” or “physical fitness equipment” or “bio-healthy park*” or “healthy park*”
3.	1 and 2
4.	Limit 3 to (english language and human and journal article)

4.3.5 Study selection and data collection

One author (N.Y.L) downloaded all articles, removed the duplicates, screened all titles and abstracts fully, and excluded inappropriate citations. The authors of two studies were contacted for more information but no response was received, so these two studies were excluded (due to not meeting the eligibility for the required age group, which was not clear from the published papers). Following this, the reference lists from the selected articles were screened to identify any additional articles meeting the inclusion criteria by N.Y.L. Two authors (N.Y.L and E.B) read each selected (full text) article independently to determine the eligibility of the article. Any disagreements were resolved between authors through discussion by referring back to the eligibility criteria.

4.3.6 Study quality

The methodological quality of all included studies was assessed by two of the authors independently (one author (N.Y.L) independently assessed all included studies, while two other authors (E.B, K.H.) shared the second assessments, assessing five and four articles respectively). Authors (K.H and P.L) were co-authors for two of the studies (Sales et al., 2018; Sales et al., 2017) and were not involved in assessing these articles. The methodological quality of studies were assessed using the following: Randomized controlled trials (RCTs) using the Cochrane Collaboration's risk of bias tool 2.0 (RoB 2.0) (Sterne et al., 2019); quantitative studies (excluding RCTs) using the National Heart, Lung and Blood Institute quality assessment tool (US Department of Health and Human Services, 2019); and qualitative studies using the Critical Appraisal Skills Program (CASP) tool (Critical Appraisal Skills Program, 2018).

The Cochrane Collaboration's risk of bias tool 2.0 (RoB 2.0) assesses bias in the following domains: arising from the randomization process, due to deviations from intended interventions, due to missing outcome data, in the measurement of the outcome, in the selection of the reported result and, overall bias (Sterne et al., 2019). Risk of bias for each domain was scored at one of three different levels: "low risk", "some concerns" and "high risk" (Sterne et al., 2019).

The National Heart, Lung and Blood Institute quality assessment tool assessed quality with 14 questions on research objective, study population, participation rate, method of recruitment, sample size, outcome(s), timeframe, levels, and assessment of exposure, outcome measures, blinding of assessors, drop-out rate and statistical analysis. Each question was scored as "yes", "no", "not applicable", "cannot determine" or "not reported" (US Department of Health and Human Services, 2019).

The Critical Appraisal Skills Program (CASP) tool assessed the quality of qualitative studies with 10 questions about research aims, method, research design, recruitment strategy, data collection, the relationship between the researchers and participants, ethical considerations, rigorousness of data, clarity of findings and the value of the research (Critical Appraisal Skills Program, 2018). Nine of the questions were assessed using responses of "yes", "can't tell" or "no" (Critical Appraisal Skills Program, 2018), while the other question was scored using responses of "high", "medium" or "low" (Coates et al., 2019).

4.3.7 Data analysis

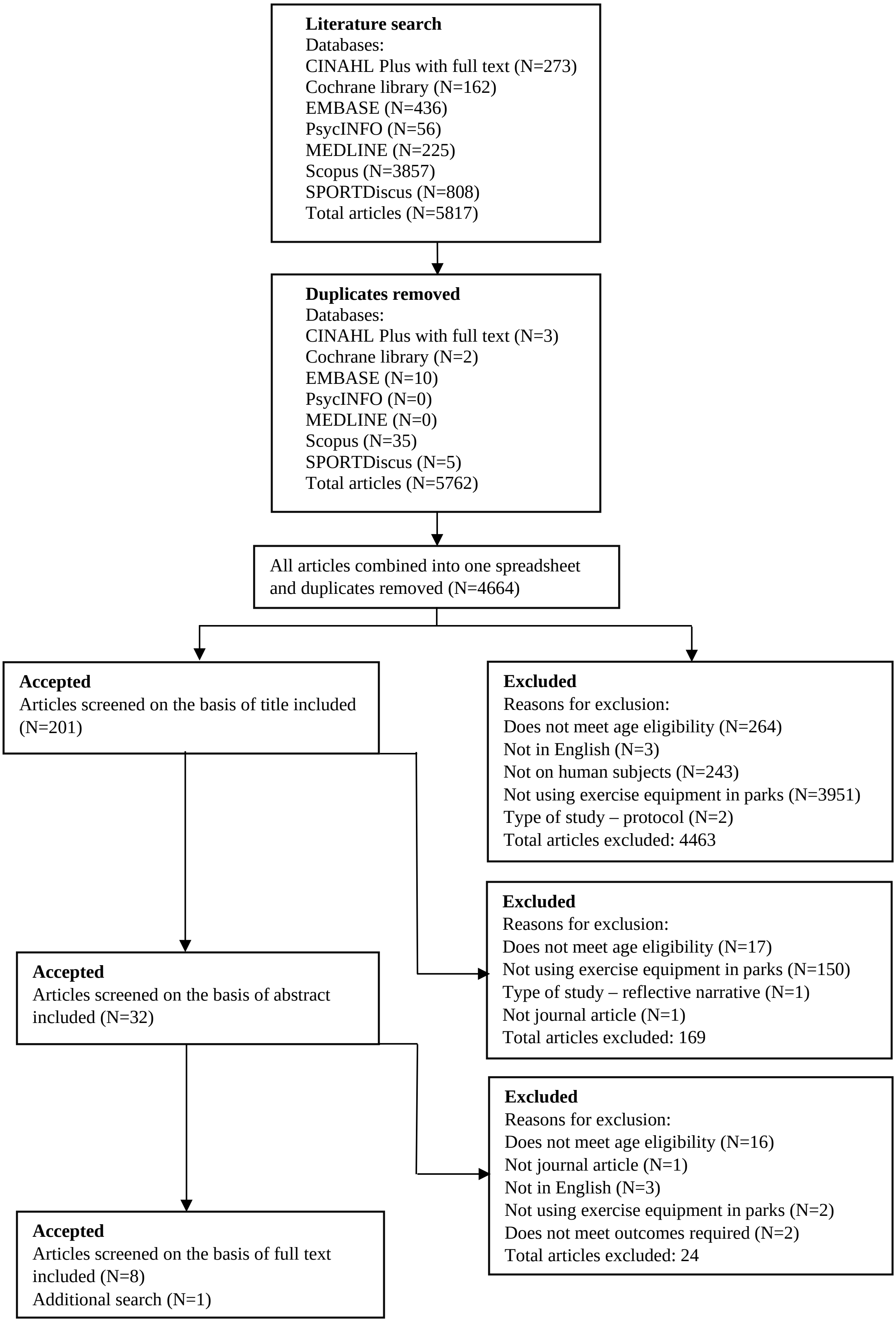
Each study selected was independently evaluated by two authors (N.Y.L and E.B) using a spreadsheet and the following information was retrieved: terminology, location, study design, aims, and participant details, details of the intervention, outcome measures and outcomes of the intervention. Meta-analysis was performed using Review Manager (RevMan) version 5.4 (The Cochrane Collaboration, 2014) where two or more studies that reported similar outcomes were able to be pooled, and forest plots were created. If a study had two intervention groups the means and standard deviations were combined (based on recommendations and the formulae provided in the Cochrane handbook (The Cochrane Collaboration, 2011) for the meta-analysis. The 95% confidence intervals (95% CI) and mean difference (MD) were calculated using a random effects model and DerSimonian and Laird's inverse variance method due to only continuous outcomes being included (DerSimonian & Laird, 1986). The forest plots were assessed for heterogeneity using I^2 and visual inspection. Statistical significance was determined for all analyses using a value of $p < .05$.

4.4 Results

4.4.1 Study selection

The search found 5,324 articles from the seven databases. Figure 4.1 presents the study selection flow chart. Duplicates were removed from within each database (N=55) and also when combined into one database (N=1098). Thirty-two full manuscript articles were read in detail and 24 articles were found not to meet the inclusion criteria. An article by Chow et al. (2017) was included in the review, as it was borderline in meeting the population criteria (48.6% instead of at least 50%). Due to the lack of research in the area, it was determined that it would add to better understanding this emerging topic because the study findings provided some evidence about the patterns and use of exercise parks by older people. One additional article was included after the reference lists of included articles were screened. A total of nine articles are included in the review.

Figure 4.1. Study selection flow chart



4.4.2 Study characteristics

Three RCTs (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Sales et al., 2017), three cross sectional studies (Chow et al., 2017; Cunha et al., 2019; Salin et al., 2014) and three qualitative studies (Chow, 2013; Chow & Ho, 2018; Sales et al., 2018) met the inclusion criteria. The number of participants ranged from nine to 303, with a median sample size of 36 and average of 75 participants. The mean age of the participants across seven studies (i.e., not reported in Chow (2013) and Chow et al. (2017)) was 71.1 (±2.5) years.

4.4.2.1 Randomized controlled trials

A summary of the three RCTs included in this review is presented in Table 4.2. Participants' average age was 71.5 (±2.1) years and sample sizes ranged from 28 to 48. The duration of interventions were six weeks (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014) and 18 weeks (Sales et al., 2017). One study recruited older people who had fallen or had fear of falling (Sales et al., 2017) and another recruited female participants with decline in balance function (Leiros-Rodríguez & García-Soidan, 2014). The third study included participants who were reported to be well for the previous six months and exercised regularly over the past three months. Interventions using the exercise park consisted of resistance and /or aerobic training (Kim et al., 2018), balance training (Leiros-Rodríguez & García-Soidan, 2014) and multi-modal training (i.e., balance, coordination, strength, mobility, flexibility, fine motor skills and range of motion) (Sales et al., 2017). The retention rates reported for all RCT studies ranged from 66.7% to 88.6% (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Sales et al., 2017), while only the Sales et al. (2017) study reported that 27 (87%) participants had a mean attendance rate of 79.6%. Adverse events were rarely reported. Only Sales et al. (2017) reported two non-injurious falls

Table 4.2. Study details for included RCTs

Study	Country	Terminology	Aims	Number of exercise stations and types of exercise	Participants (sample size, female (n (%), mean age (SD)) and sample population	Intervention using outdoor exercise park equipment	Intervention duration	Exercise park equipment outcomes, adherence (completion of program) and adverse event
Kim et al. (2018)	Republic of Korea	"Outdoor exercise equipment"	Effects of resistance training or combined resistance and aerobic training using outdoor exercise park to changes in insulin, insulin resistance, adipocytokine levels and fitness	5 Resistance and aerobic	35; 32 females (91.4%); 73.2 (4.9) years Healthy community-dwelling	IG1: Resistance training, 70 minutes, supervised by certified trainers, IG2: aerobic and resistance training, 90 minutes, supervised by certified trainers, C: Not in text	6 weeks	IG1 vs. C: post-test ($p < 0.05$) for push-up and 6 min walk, IG2 vs. C: post-test ($p < 0.05$) for push up, 6 min walk and step test, Retention rate: IG1: 12 (75%), IG2: 13 (81.3%), C: 10 (66.7%), Adverse event: Not reported
Sales et al. (2017)	Australia	"Exercise park"	Evaluate feasibility, the effectiveness of outdoor exercise park in improving physical function, quality of life and balance	16 Balance, coordination, strength, mobility, flexibility, fine motor skills and range of motion	48; 34 females (70.8%); 72.7 (2.5) years Community-dwelling, fallen in previous year, concerned about falls	I: Multi-modal training, 1-1.5 hours, twice weekly, supervised by accredited exercise physiologist, C: Social activities, 2 hours each session, fortnightly	18 weeks	I vs. C: post-test ($p<0.05$) for single leg stance, knee strength, 2-min walk, timed sit to stand, Retention rate: I: 27 (77.1%), C: 21 (67.7%), Adverse event: Two falls, with no injuries occurred during the exercise sessions.
Leiros-Rodriguez and Garcia-Soidan (2014)	Spain	"Equipment of a public park"	Whether exercise park improved general health and balance	12 Static balance, dynamic balance	28; 28 females (100%); 68.5 (2.9) years Community-dwelling, decline in balance	I: Balance training, 50 minutes, twice weekly, supervised by a physical therapist, C: "Normal life"	6 weeks	I vs. C: post- test ($p<0.05$) for Berg Balance Scale, timed up and go test, SF-12, Retention rate: I: 14 (66.7%), C: 14 (66.7%), Adverse event: Not reported

Note. I = intervention; C = control group; G = group; SD = standard deviation.

Sales et al. (2017) retention rate was defined by participants' attending to intervention more than 50% of the sessions. Kim et al. (2018) and Leiros-Rodriguez and Garcia-Soidan (2014) retention rate was defined by participants' completing the program and follow-up assessments.

while using the exercise park equipment. The authors reported that there was no delayed onset muscle soreness or fatigue experienced by the participants throughout the intervention although the participants were exercising with a rate of perceived exertion (RPE) between ‘somewhat hard’ and ‘very hard’(Sales et al., 2017).

Kim et al. (2018) assessed the effects of resistance training or combined (i.e., resistance and aerobic) training on insulin resistance, adipocytokines and fitness (i.e., consisting of seven tests) in healthy community-dwelling older people. Only outcomes concerning physical function are reported. Both intervention groups had significant improvements in upper body strength (push-up test) and endurance (6-minute walk test) compared to the control group. However, only the combined training group achieved a significant improvement for dynamic standing balance (2-minute step test). The authors acknowledged that they were unable to differentiate whether the improvements were caused by the amount or mode of exercise due to the different durations allocated to the intervention groups (i.e., 70 minutes for the resistance training group and 90 minutes for the combined training group).

Leiros-Rodríguez and García-Soidan (2014) evaluated the effects of balance training in older people with balance issues. Significant improvements were found in Berg’s balance scale, the timed up and go (TUG) test and the SF-12 at the end of six weeks compared to the control group. It must be noted that two of the sessions were conducted at an alternative venue instead of an exercise park due to the weather. Although improvements were demonstrated, the results may not be generalizable because only women were recruited for this study. This was acknowledged as a limitation by the authors. Sales et al. (2017) evaluated the effectiveness of exercise park training in older people who had fallen in the previous year or had fear of falls. No significant improvements were found in The Balance Outcome Measure for Elder

Rehabilitation (primary outcome) or in some of the secondary outcomes (i.e., gait speed, fear of falling, quality of life and hand grip strength). Significant improvements were found over time in secondary physical function outcomes (i.e., knee strength, 2-minute walk test, sit-to-stand test and single leg stance) when compared to the control group.

4.4.2.2 Cross sectional studies

Three cross sectional studies were included in this review (see Table 4.3). The sample size for the cross sectional studies ranged from nine to 303. The average age was 70.5 (±0.2) years for two studies (Chow & Ho, 2018; Cunha et al., 2019) while average age was not reported by Chow et al. (2017). Chow et al. (2017) was the only study to evaluate the user characteristics and patterns of exercise park use. Older people tended to use exercise parks in the morning (before 9 am), average time spent using exercise equipment unsupervised was short (on average nine minutes 49 seconds), however it was higher compared to other age groups (Chow et al., 2017). Chow and Ho (2018) evaluated four types of exercise park equipment and discovered that the air walker and ski machine (i.e., aerobic training equipment) were able to provide moderate-intensity physical activity when performed at a higher tempo of 100 and 120 beats per minute using a metronome. Flexibility training equipment such as waist twister (i.e., flexibility training equipment) and double arm stretch (i.e., stretching training equipment) were considered light intensity physical activity (Chow & Ho, 2018). Cunha et al. (2019) evaluated aerobic and resistance training performed using outdoor gym equipment for 40 minutes and found that the bout of exercise was equivalent to moderate to vigorous-intensity physical activity.

Table 4.3. Study details for included cross sectional studies

Study	Country	Terminology	Aims	Number of exercise stations and types of exercise	Outcome measure	Participants (users of exercise park equipment (%), female ((%), mean age (SD)) and sample population	Exercise park outcomes
Chow et al. (2017)	Taiwan	"Outdoor fitness equipment"	Identify use, user characteristics and patterns	6 Flexibility, aerobic and range of motion	System for Observing Play and Recreation in Communities (SOPARC)	303 (48.6%) Gender: Not reported; Mean age: Not reported. Healthy community-dwelling	260 (52.5%) seniors, which was the largest group to use exercise park compared to children (*p* < .001), youths and adults. Older people used exercise park before 9 am. The total time spent on exercise park was 9.49 (7.48) minutes.
Chow and Ho (2018)	Taiwan	"Outdoor fitness equipment"	Evaluate the intensity of activity when using exercise park equipment	4 Flexibility and aerobic	Short survey, energy expenditure and intensity of activity	16 (100%); 8 (50%) females; 70.7 (5.6) years Healthy community-dwelling	7 (44%) visited parks regularly, 9 (56%) did daily exercise and 3 (19%) did not do consistent physical activity. The air walker and waist twister were popular among the participants. Exercise performed at various tempos (80, 100, 120 bpm) registered MET values of 2.81 to 3.55 for the air walker, and 3.02 to 4.05 for ski machine. These two pieces of equipment can provide moderate-intensity physical activity if used appropriately at higher tempos. The waist twister and double arm stretch only provided light-intensity physical activity.
Cunha, Gomes, Carvalho and Silva (2019)	Brazil	"Concurrent exercise", "Third Age Academies"	Evaluate energy cost and metabolic intensity	11 Resistance and aerobic	Metabolic equivalent of task (METS), % heart rate reserve, oxygen uptake reserve	9 (100%); 4 (44%) females; 70.3 (4.8) years Healthy community-dwelling who did physical activities ≥ 2 months, 2 to 3 times per week, 20 to 60 minutes per session	The exercise park was able to provide moderate intensity physical activity when all exercise stations were completed in a circuit for 40 minutes. Mean observed METS value = 4.6 METS (p = 0.002), mean oxygen uptake reserve = 51.5% (p = 0.040) and 64.1% heart rate reserve (p < 0.001).

Note. SD = standard deviation; MET = metabolic equivalents.

4.4.2.3 Qualitative studies

A summary of the three qualitative studies in this review are presented in Table 4.4. The sample size for the studies involving qualitative methods ranged from 27 to 163 and the average age of participants for two studies was 71.2 (±3.9), while the average age was not reported by Chow (2013). Chow (2013) explored perceptions of older people and found that utilizing the exercise park equipment was often done in conjunction with walking and group exercise. The primary purpose for using exercise parks was to improve health; and improved health, mood and social interaction were the perceived benefits of outdoor exercise equipment use (Chow, 2013). Salin et al. (2014) found that intrinsic factors such as the pursuit of good health and perceived benefits of exercise were the main factors for commencement and adherence to the Golden age gym program respectively (i.e., outdoor exercise park for older people). Frequently cited factors influencing program commencement were for improving health (90.8%) and encouragement by others (29.6%). Factors influencing adherence to the program were the opportunity for socialization (72.7%), benefits of exercise (45.4%) and feeling positive (26.9%) (Salin et al., 2014). Sales et al. (2018) explored perceptions of older people who participated in the Sales et al. (2017) randomized trial of an outdoor exercise park program and found that social benefits, availability of supervision and physical health were the most cited benefits of their program.

Improvements to health and social interaction were the main benefits cited by older people from use of outdoor exercise parks (Chow, 2013; Sales et al., 2018; Salin et al., 2014). Social interaction was highly valued because of the opportunity to meet new people and form friendships (Chow, 2013; Salin et al., 2014).

Table 4.4. Study details for included qualitative studies

Study	Country	Terminology	Aims	Number of exercise stations and types of exercise	Outcome measure	Participants (users of exercise park equipment (%), female ((%), mean age (SD)) and sample population	Exercise park outcomes
Chow (2013)	Taiwan	"Outdoor fitness equipment"	Understand the use of fitness equipment, suggestions for improvement and perceptions of health benefits	12 Flexibility, aerobic and range of motion	Semi-structured interview	36 (65%); Gender: Not reported; Mean age: Not reported; Healthy community-dwelling	Using exercise park was a secondary activity. The primary purpose was to improve health and to exercise. Perceived benefits were improved health, social interaction and improved mood. Suggestions: install different equipment, provision of shade and the necessity of maintenance.
Salin et al. (2014)	Brazil	"Golden age gym", "Third age fitness center", "Facilities in public parks"	Whether participants were satisfied, what were the suggestions and reasons for participating in the "Golden age gym" program	10 Flexibility, aerobic and resistance	Semi-structured interviews and two closed questions using Likert scale	163 (100%); Gender: Not reported; 67.22 (5.87) years; Community-dwelling who participated in the Golden age gym for a minimum of 6 months	Most frequently cited reasons (in descending order) for: (a) entering the "Golden age gym" were for good health (90.8%), encouragement by friends, neighbors, and children (29.6%); and (b) adherence including socialization (72.7%), benefits of exercise (45.4%), feeling positive (26.9%). Suggestions: install different equipment and cover to protect the exercise parks from inclement weather.
Sales et al. (2018)	Australia	"Exercise parks", "Senior exercise parks"	Understand the facilitators and barriers, health benefits and outcomes of the exercise park program	16 Balance, coordination, strength, mobility, flexibility, fine motor skills and range of motion	Semi-structured interview	27 (100%); 17 (63%) females; 75.1 (7.9) years; Community- dwelling, fallen in the previous year or concerned about falls	Social benefits, availability of supervision and physical benefits were the most cited benefits. Physical ability, daily activity, confidence, and well-being were perceived as improvements after the program. The weather conditions were considered a major barrier to participation. Suggestions for improvement were increased frequency of sessions, free access and water-proof exercise park from weather inclement.

Note. SD = standard deviation.

Weather conditions (i.e., hot, windy or wet) were considered a barrier to participation, however in Sales et al.'s (2017) trial only 9.6% of the outdoor exercise sessions were cancelled due to weather conditions. Participants from two studies requested a covered exercise park and installation of a variety of outdoor equipment (Chow, 2013; Salin et al., 2014).

4.4.3 Quality of studies

4.4.3.1 Randomized controlled trials

One study (Sales et al., 2017) had low risk of bias across two domains and high risk of bias across four domains. Leiros-Rodríguez and García-Soidan (2014) were assessed as having some concerns across five domains and high risk in one domain, whereas the third study (Kim et al., 2018) had some concerns across all domains. Overall, the studies were rated as high risk of bias (see Table 4.5).

4.4.3.2 Cross sectional studies

Two studies (Chow & Ho, 2018; Cunha et al., 2019) had an overall rating of good and one article was rated as fair (Chow et al., 2017). In general, all studies lacked sample size justification and some items were not applicable across all studies (see Table 4.6).

4.4.3.3 Qualitative studies

Only one study (Sales et al., 2018) met all the criteria of the CASP. The ratings "Could not tell" or "No" were used to assess up to three of the criteria in two of the studies (Chow, 2013; Salin et al., 2014), when limited or no information was provided (see Table 4.7).

Table 4.5. Assessment of risk of bias for included RCT studies

Study	**Randomization process**	**Deviations from intended outcome**		**Missing outcome data**	**Measurement of the outcome**	**Selection of the reported result**	**Overall**
		Assignment to intervention	**Adherence to intervention**				
Leiros-Rodriguez and Garcia-Soidan (2014)	×	×	×	×	●	×	●
Sales et al. (2017)	○	●	○	●	●	●	●
Kim et al. (2018)	×	×	×	×	×	×	●

Note. Bias was scored as low risk = ○; some concerns = ×; or high risk = ●.

Quality of included studies was assessed using the Cochrane Collaboration's risk of bias tool 2.0 (RoB 2.0).

Table 4.6. Results of quality assessment of the cross sectional included studies

Study	Criteria														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Quality**
Chow et al. (2017)	✓	✓	NA	✓	✗	NA	NA	NA	✓	NA	✓	NA	NA	NA	Good
Chow and Ho (2018)	✓	✗	NR	✓	✗	✗	✓	✓	✓	✗	✓	NA	NA	NA	Fair
Cunha, Gomes, Carvalho and da Silva (2019)	✓	✓	NR	✓	✗	✗	✓	✓	✓	✓	✓	NA	NA	✓	Good

Note. ✓ = Yes; ✗ = No; NR = Not reported; NA = Not applicable.

Quality of included studies was assessed using the National Heart, Lung and Blood Institute Quality Assessment Tool.

Criteria:

1. Was the research question or objective in this paper clearly stated?
2. Was the study population clearly specified and defined?
3. Was the participation rate of eligible persons at least 50%?
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?
5. Was a sample size justification, power description, or variance and effect estimates provided?
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
10. Was the exposure(s) assessed more than once over time?
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
12. Were the outcome assessors blinded to the exposure status of participants?
13. Was loss to follow-up after baseline 20% or less?
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Table 4.7. Results of quality assessment of the qualitative included studies

Study	Criteria									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Chow (2013)	✓	✓	✓	✓	✓	?	✓	✓	✓	High
Salin et al. (2014)	✓	✓	✓	✓	?	✓	✓	✗	?	Medium
Sales et al. (2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	High

Note. ✓ = Yes; ✗ = No; ? = Could not tell.

Quality of included studies was assessed using the Critical Appraisal Skills Program (CASP) tool.

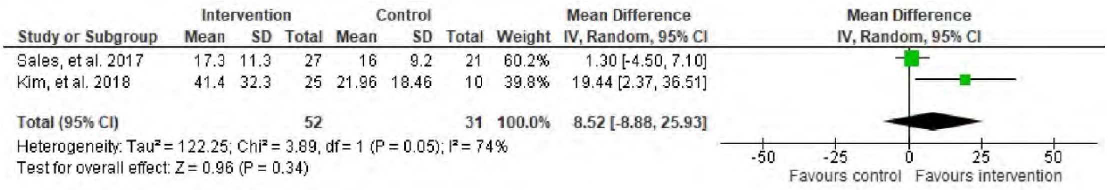
Criteria:

1. Was there a clear statement of the aims of the research?
2. Is a qualitative methodology appropriate?
3. Was the research design appropriate to address the aims of the research?
4. Was the recruitment strategy appropriate to the aims of the research?
5. Was the data collected in a way that addressed the research issue?
6. Has the relationship between researcher and participants been adequately considered?
7. Have ethical issues been taken into consideration?
8. Was the data analysis sufficiently rigorous?
9. Is there a clear statement of findings?
10. How valuable is the research?

4.4.4 Meta-analysis

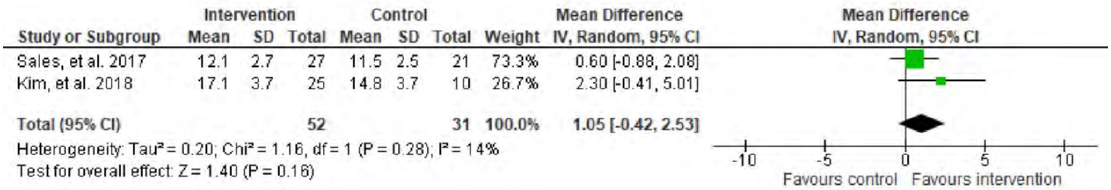
A meta-analysis was performed with two studies (Kim et al., 2018; Sales et al., 2017) for the outcome measures of single leg stance (see Figure 4.2) and 30 seconds chair stand test (see Figure 4.3). Medium to high heterogeneity was found between the two studies for the single leg stance analysis (I^2=74%) and low heterogenity for the 30 seconds chair stand test analysis (I^2=14%).

Figure 4.2. Forest plot of comparison: Outdoor exercise parks versus control for mean single leg stance



Note. CI = confidence interval; IV = inverse variance; SD = standard deviation.

Figure 4.3. Forest plot of comparison: Outdoor exercise parks versus control for mean 30 seconds chair stand test



Note. CI = confidence interval; IV = inverse variance; SD = standard deviation.

Weights were assigned by the RevMan program, studies with larger sample sizes and smaller standard errors are given a higher weight than smaller studies with larger standard errors. Higher percentage weights were assigned to Sales et al's. (2017) study due to these factors. The difference between intervention and control groups was not statistically significant for either test: single leg stance (MD [95% CI]=8.52 [-8.88 to 25.93]); the 30 seconds chair stand test (MD [95% CI]=1.05 [-0.42 to 2.53]). Another meta-analysis of two studies reporting the TUG as an outcome measure (Leiros-

Rodríguez & García-Soidan, 2014; Sales et al., 2017) was also performed. However, very high heterogeneity was found for this analysis (I^2=98%), therefore the forest plot has not been included in the summary.

4.5 Discussion

The objective of this review was to synthesize the evidence regarding the use and the effects of exercise parks on physical activity levels, physical function, psychosocial and quality of life among older people. The meta-analyses did not identify that the use of exercise parks resulted in any significant improvements in the physical function outcomes when the data were pooled, although individual studies did report some significant improvements. Older people reported some positive perceptions about the use of outdoor exercise parks such as an improvement in their health and the opportunity for social interaction with other people. It was not possible to conclude whether exercise parks were effective at improving levels of physical activity due to no RCT including this as an outcome measure.

4.5.1 Physical function and quality of life

Three studies evaluated the effects of outdoor exercise park equipment use on physical function and quality of life outcomes among older people. The type of training provided was different across RCTs; resistance and combined (resistance and aerobic) exercises (Kim et al., 2018), multi-modal exercises (Sales et al., 2017) and balance exercises (Leiros-Rodríguez & García-Soidan, 2014). Although the type of training was different, the RCTs demonstrated significant changes to some physical function tests (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Sales et al., 2017) and quality of life (Leiros-Rodríguez & García-Soidan, 2014) after intervention, which provide some evidence that exercise parks may help to improve some aspects of an older person's health.

The meta-analysis results were not significant for the two physical function outcomes that were reported in multiple studies. The lack of significant findings may be due to inconsistencies between the studies, such as differences in the duration of each session and overall length of the program, different load, type and intensity of exercises provided to the participants, diversity of the samples, different number of equipment at each exercise park, lack of consistent measures of physical function between studies, limited number of studies in this research area and the small sample sizes of each study. In order to compare studies in the future it is recommended more information be provided about the use of the exercise park equipment, particularly load, sets and repetitions.

4.5.2 Adherence

High adherence and retention rates in the three RCT studies (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Sales et al., 2017) may be due to the level of supervision provided. Older people perceived supervision as motivating and the feedback of practicing correct form during exercise was important (Sales et al., 2018). Also, supervised exercise park classes have been reported to attract new users and increased the confidence of older people using the equipment correctly (Scott et al., 2014). However, from a sustainability perspective, future studies should explore lower supervision levels and independent use of exercise parks for those when this is safe to do so and define and standardize the reporting of adherence such as completion of the exercise program (i.e., retention), proportion sustaining long-term participation after the supervised exercise program has ceased, adherence to the intensity of prescribed exercises and percentage of classes attended.

4.5.3 Adverse events

Knowledge about adverse events can guide intervention practice and improve safety (Liu et al., 2016) of exercise park programs. No injuries were reported by the three RCTs (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Sales et al., 2017). Other research has shown that 47% of older people did not follow the manufacturer's instructions of correct equipment use when using outdoor exercise equipment (i.e., the waist/back massager, ski machine, waist twister and air walker), which potentially puts them at risk of injuries (Chow & Wu, 2019). Therefore, the provision of some initial supervision and advice regarding correct use and appropriate level of exercise on the exercise park equipment for older people may keep the risk of injuries to a minimal level.

4.6 Limitations and strengths

This systematic review included quantitative and qualitative research studies. Language bias may have occured because only articles published in English were included in this review. Although seven databases were searched from inception to January 2020 and every effort was taken to include all articles which met the inclusion criteria, there may be a possibility that one or more articles were missed. The nine studies included in the review used different methodologies, differing number and various types of exercise park equipment and different outcome measures, which made it difficult to compare the effectiveness across the studies. Although the three RCTs (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Sales et al., 2017) had different load, type and intensity of exercises provided to the participants, the studies were aimed at using outdoor exercise equipment to improve health outcomes. Hence, it was considered appropriate to combine them into meta-analyses to provide preliminary data to inform our understanding of physical activity using outdoor exercise equipment in exercise parks among older people. The results in this review should be interpreted with caution because two of the measurement outcomes had medium to very high heterogeneity in the meta-analysis.

The review revealed that the majority of studies were considered low quality because the studies did not meet all criteria of the respective quality assessment tools except the Sales et al. (2018) study. Although the quality of the studies was not high, the findings of these studies offered some perspective on the usage and effectiveness of outdoor exercise parks.

The present review shows some evidence that older people use outdoor exercise parks in the morning for an average of 10 minutes, however there are currently not enough studies to clearly establish the reasons for this observed pattern and duration of use. Possible explanations for morning use of exercise parks may include that it is a preferred time to perform physical activity; that it is a time that they do not have any other commitments, or possibly due to cooler weather at this time of day. The reasons for the short duration may include older people performing other activities at the exercise parks such as social activities (i.e., chatting with friends or having a social gathering) (Cohen et al., 2007) and/or other forms of physical activity (i.e., walking or group exercise) (Chow, 2013), or perhaps limited knowledge about the amount of physical activity needed to maintain or improve health (Grossman & Stewart, 2003; Prokop et al., 2014).

The majority of the equipment was installed to improve flexibility and/or for aerobic and/or resistance training. Only two RCTs included balance training using outdoor exercise parks. This could be due to the lack of balance exercise park equipment which was identified by Lee et al. (2018) as a gap in the type of exercise available in many of the existing outdoor exercise parks. Exercises targeting a combination of balance, resistance and functional exercises have been shown to prevent falls (Sherrington et al., 2019).

4.7 Conclusion

To our knowledge, this is the first review of outdoor exercise park equipment usage and the outcomes associated with their use by older people. The meta-analysis results were not significant for single leg stance and 30 second chair stand test. It was not possible to conclude whether outdoor exercise parks were effective at improving levels of physical activity due to no RCT including this as an outcome measure. Data from individual studies indicates that exercise park programs may improve quality of life and provide opportunities for social interaction (i.e., psychosocial outcome). Findings from this review suggest that older people use outdoor exercise park equipment while performing other activities at the park. Exercise park programs supervised by health professionals may encourage adherence to physical activity programs among older people. Future research should include measuring the levels and intensity of physical activity, larger sample sizes and higher quality research methods, use similar type of exercise park equipment, consistent measurement outcomes, and ensure adequate prescription and progression of exercise to better determine the effectiveness of outdoor exercise parks.

Chapter 5 : Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment

Chapter outline

Several balance outcome measures are prone to ceiling effects when evaluating older adults who are higher functioning. The CBMS demonstrated a lack of ceiling effects in independent, community ambulant older adults. However, the CBMS required a large space and a flight of stairs which limited its implementation for assessments in the community. This chapter presents the findings of a study investigating the measurement properties of a modification to the CBMS developed for settings with limited space (known as CBMS-Home).

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5.1 Abstract

Background: The Community Balance and Mobility Scale (CBMS) has been shown to be a valid and reliable outcome measure for evaluating balance and mobility amongst older adults. However, some items are not able to be conducted in all home environments, limiting its use in home-based assessments.

Objective: To evaluate the accuracy and selected measurement properties of a modified 12-item CBMS-Home (i.e., eight original items and four modified items of the CBMS) feasible for use within the constraints of home assessments for older adults.

Design: Validation study.

Methods: Fifty-five people (mean (SD) age = 77.2 (6.0 years) were recruited. Participants completed the full original CBMS, CBMS-Home (i.e., the modified items of the CBMS), the Functional Reach Test (FRT), and Step Test (ST). Principal component analysis, internal consistency, test-retest and inter-method reliability, agreements within and between methods, and criterion validity were calculated.

Results: Principal component analysis of CBMS and CBMS-Home both revealed three similar components and loadings. Bland-Altman and Weighted Kappa analyses revealed that the CBMS-Home demonstrated moderate to almost perfect agreement (K_W = 0.45-0.84; $p < .001$) with CBMS. The distribution of scores of CBMS-Home were satisfactory, and other results showed excellent test-retest (ICC = 0.95; $p < .001$) and inter-method reliability (ICC = 0.94; $p < .001$) and internal consistency (Cronbach's alpha = 0.94; $p < .001$). There were no ceiling (0%) or floor (1.8%) effects. CBMS-Home demonstrated a low (Spearman ρ = 0.39; p = .003) and moderate positive relationship (Spearman ρ = 0.63; $p < .001$) with the FRT and ST respectively.

Conclusion: The CBMS-Home has good psychometric properties and provides a useful multidimensional assessment tool.

Impact statement: A modified version of the Community Balance and Mobility Scale (CBMS-Home) was developed that can be confidently used in the same way as the CBMS to assess older adults who may have mild balance impairments, but within their homes.

5.2 Introduction

The percentage of older adults in the world is projected to rise to 16% by 2050 (World Health Organization, 2011). This increase in the aging population has implications for public health, because the aging process is often associated with reduced function and health (Diehr et al., 2013). Balance and mobility are important areas to assess to determine the functional level of older adults living in the community, screen for risk of falls and determine whether further treatments such as exercise interventions are needed (Boulgarides et al., 2003).

Physiotherapists play an important role in the care of older adults such as performing assessments, developing treatment plans, providing treatment and educating older adults and caregivers (Guccione & Elrod, 2012). The ability of the physiotherapist to perform an accurate assessment of physical function and mobility can help guide effective management of older adults. To improve the accuracy of assessment, an outcome measure needs to be appropriate for the population, feasible for implementation and have adequate psychometric properties (i.e., validity, reliability and responsiveness) (VanSwearingen & Brach, 2001).

A number of commonly used balance and mobility tests are limited in detecting mild balance impairments in older adults who are relatively active and living independently in the community. For example, the Berg Balance Scale (Miyata et al., 2020; Pardasaney et al., 2012; Rudolf et al., 2020), Short Physical Performance Battery (Tangen & Robinson, 2020), the Dynamic Gait Index (Pardasaney et al., 2012), and Tinetti Performance Oriented Mobility Assessment (Pardasaney et al., 2012) have been shown to have ceiling effects in various populations. The Community Balance and Mobility Scale (CBMS) has been proposed as a comprehensive balance and mobility test for higher functioning community-dwelling older adults that does not have ceiling effects. It was assessed as being a valid and reliable outcome measure (Balasubramanian, 2015; Weber et al., 2018). The CBMS has also been validated for use in older adults after stroke (Knorr et al., 2010), cardiac rehabilitation (Martelli et al., 2018), and knee osteoarthritis (Takacs et al., 2014). Absence of ceiling effects implies that CBMS is sensitive enough to detect changes in balance and mobility and treatment-related improvements over time in active and independent older adults. Previous research have proposed for a short form of CBMS, however there has been little discussion about modifying the CBMS for home use (Balasubramanian, 2015).

The original CBMS (i.e., 13-items) has been reported to take 15 (Takacs et al., 2014) to 30 minutes (Howe et al., 2011) to complete. A shortened version of the CBMS which consisted of four items ('hop forward', 'lateral foot scoot', 'unilateral stance', and 'walk, look and carry') was validated against the original CBMS amongst younger seniors (i.e., 61 to 70 years of age) (Gordt et al., 2020). Although the shortened version reduced the administration time to 10 minutes (Gordt et al., 2020), the requirement of a 10 meter space (i.e., performance of item is assessed on an eight-meter walkway) limits the pragmatic use of the tool due to constraints of space in older adults' homes. Also, balance is a complex skill which requires different body systems (i.e., vestibular, somatosensory, vision and musculoskeletal) to work together to control posture (Wallmann, 2009). Therefore, a variety of tasks while walking and standing need to be included to assess different facets of balance (Vereeck et al., 2008). The remaining combination of items in the shortened version of CBMS may not be adequate to assess these different facets of balance.

Although the full CBMS is a useful outcome measure with a variety of items to assess an older adult's balance and mobility, one issue that may limit the practical use of the CBMS in the community setting is the equipment (stairs) and space required. The

CBMS has some items that are not able to be performed in many homes (e.g., one item requires a minimum of 8 steps on a flight of stairs) and four items are assessed on an eight-meter walkway (e.g., 'forward to backward walk'). For this reason, CBMS-Home was developed (this study) by reducing the length of the walkway to four meters for four of the items (i.e., 'walk and look', 'walk, look and carry', 'run with a controlled stop' and 'forward to backward walk'), modifying the associated scoring criteria for these items, and to explore whether 'descending stairs' could be removed without affecting measurement properties. Prior to being able to use CBMS-Home in an older adult's home, it is important to know whether CBMS-Home is reliable and valid compared to the original CBMS. This will not only benefit older adults who are unable to attend a physiotherapy or health clinic but also offer physiotherapists and researchers an additional outcome measure for assessment in the community.

The aim of this study was to evaluate (1) selected measurement properties of the 12-item CBMS-Home (i.e., eight original items and four modified items of the CBMS) that are feasible for use within the constraints of home assessments for older adults, and (2) the accuracy of the 12-item CBMS-Home in evaluating balance and mobility related physical performance, relative to the original 13-item CBMS.

5.3 Methods

5.3.1 Study design

This was a validation study and CBMS-Home was evaluated following the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) study design checklist (Mokkink et al., 2019).

5.3.2 Participants

Participants were recruited from a research volunteer database, by flyer at a retirement village, and through word of mouth. Retirement villages are a clustered housing environment built to support older adults who remain relatively independent, with convenient access to relevant facilities and organized social activities (Gardner et al., 2005). Participants who were interested in participating in the study were screened by telephone to determine whether they met the inclusion criteria. Data were collected in the homes of participants if they agreed to this and had adequate space to test the modified and original items of CBMS, or alternatively, at a retirement village with a suitable area with adequate space and stairs to conduct the full CBMS. Recruitment and assessment occurred between November 2019 and March 2020.

Inclusion criteria were: community-dwelling people aged 65 years or older, able to understand spoken and written English, and able to walk independently with or without a walking aid. Older adults with chronic neurological problems such as stroke and Parkinson’s disease who met the inclusion criteria were eligible to participate. Exclusion criteria were: requiring one adult supervision or assistance during daily tasks and mobility such as transfers, standing up and walking, or uses a wheelchair for mobility indoors/or outdoors.

5.3.3 Procedure

Participants completed a questionnaire about their age, health, medication history, and history of falls in the previous year. For this study, a fall was defined as an older adult “coming to rest on the ground or another lower level” unintentionally (World Health Organisation, 2007, p. 1). Participants were then asked to complete the full original CBMS, CBMS-Home (i.e., the modified items of the CBMS), the Functional Reach

Test (FRT) and Step Test (ST) in a fixed order of assessment (the latter two tests used to evaluate concurrent validity). The physiotherapist demonstrated each assessment item while instructing the participant. The participant was scored on the first trial of each item of the CBMS (Howe et al., 2011) and CBMS-Home modified items. If participants did not understand the item, repeat instructions were provided and a second trial was performed. Participants wore their own comfortable shoes and a safety gait belt so that the physiotherapist could steady them if there was any sudden loss of balance during performance of the item. Participants were provided with rest periods between items if required, up to a duration of 5 minutes. The participants were assessed on all items on two separate occasions, with assessments conducted five to ten days apart. Participants who declined to perform any test or were unable to complete any item safely or independently were scored '0-unable' (i.e., the lowest score for the item).

5.3.4 Outcome measures

5.3.4.1 Original CBMS

The CBMS measures balance and mobility performance. It consists of 13- items, with each item scored on a scale of 0 to 5, with 0 indicating not able to perform the item and 5 indicating the item was completed within a certain time, distance and with normal movement (Howe et al., 2011). The description of the scoring and items is described in the study by Howe et al. (2006). Eleven items are performed on an eight-meter track, one item performed on a single step and one item performed on a flight of stairs (≥ eight steps), for a total of 13 items, with six items performed bilaterally for a total score of 95 points (Howe et al., 2006). A bonus point is given for carrying a weighted box while descending stairs, thus the maximum score is 96 points (Howe et al., 2006).

5.3.4.2 CBMS-Home (modification of some items in CBMS)

The CBMS was modified by reducing the length of the walkway used for four items from eight meters to four meters and modifying the scoring criteria for the five-point scales for these items to accommodate this change. These four modified CBMS items using the four-meter walkway included ‘forward to backward walk’, ‘walk and look’, ‘walk, look, carry’ and ‘run with controlled stop’. Therefore, CBMS-Home consists of four modified items and eight original items of CBMS (i.e., ‘descending stairs’ is removed, as is not likely to be able to conduct, even in a modified way, within many homes of older adults). The maximum score for CBMS-Home is 90 points. Chapter 3 (see Table 3.2 and Figure 3.3) provide details of the modified walkway, modification of items and scoring instructions.

5.3.4.3 Validation of CBMS-Home with other measures

The FRT and the ST were used to evaluate the criterion validity of the CBMS and CBMS-Home:

(i) The FRT was used to assess the ability of the participant to reach forward while standing with feet positioned 10 cm apart (Duncan et al., 1992; Duncan et al., 1990). The participant reached forward using their dominant hand. The non-dominant hand was used if the participant had musculoskeletal conditions limiting the movement of the dominant shoulder. The average score of two measurements was reported.

(ii) The ST was used to assess the ability of the participant to perform dynamic single limb stance stepping tasks (Hill, Bernhardt, et al., 1996). Participants were allowed several practice steps for each foot before the test. The number of times a participant stepped one foot fully on, then off a 7.5cm block as fast as possible in 15 seconds was assessed (Hill, Bernhardt, et al., 1996). Participants were assessed without the use of walking aids or any hand support. Separate scores were obtained for each foot stepping on/off the block on a single trial. The worst score was reported and used for data analysis, as has been reported previously (Yang et al., 2012).

5.3.5 Statistical analysis

All data were calculated using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA) and the significance level was set to $p < .05$. All data were checked for normal distribution using the Kolmogorov-Smirnov statistic.

5.3.5.1 Analyses of validity

Principal component analysis (PCA) was performed to determine components of CBMS. The suitability of the data for PCA was assessed using recommended criteria by Pallant (Pallant, 2016). Oblique rotation was performed to improve interpretation of the components (Tabachnick & Fidell, 2013) of CBMS and CBMS-Home. Items with loading of 0.3 and above on the pattern matrix were considered as relevant. No specific cut-off value was used to indicate when cross-loading was significant or relevant. However, where an item cross-loaded onto more than one component at a level above the 0.3 cut-off for inclusion in the matrix, these were inspected to identify differences between the highest loading, and other loadings above 0.3.

The CBMS and CBMS-Home were assessed on the total score (adjusted to percentages). Paired t-tests were used to compare percentage scores between the two tools (or non-parametric equivalent if data were not normally distributed).

The criterion validity of the CBMS and CBMS-Home were evaluated by calculating the Spearman's rho correlation coefficient between these total scores and FRT (cm) and ST (number of steps in 15 seconds). The strength of the relationship was evaluated as follows: more than 0.9: very high, 0.7 to 0.9: high, 0.5 to 0.7: moderate, 0.3 to 0.5: low, and less than 0.3: negligible (Mukaka, 2012).

5.3.5.2 Ceiling and floor effects

Score distributions (i.e., scores should span across the entire range of the measure), ceiling and floor effects (i.e., > 15 % scored the lowest or highest score), and a mean score near the mid-point of the measure were assessed (Chou et al., 2006; McHorney & Tarlov, 1995).

5.3.5.3 Analyses of reliability

Agreements were assessed between CBMS and the modified items included in CBMS-Home (i.e., four items) during day one; and individual items on both days for CBMS and CBMS-Home respectively were analyzed using weighted kappa (K_W) with linear weights. Weighted kappa values were rated as ≤0.20: nil to slight, 0.21 to 0.40: fair, 0.41 to 0.60: moderate, 0.61 to 0.80: substantial, and 0.81 to 1.00: almost perfect (Landis & Koch, 1977).

The Bland-Altman method was used to examine the limits of agreement (Bland & Altman, 1999) between CBMS and CBMS-Home at day one. Both scores were converted to percentage (due to differences in maximum total scores between CBMS and CBMS-Home). The y-axis demonstrated the difference in scores of the two measures (i.e., CBMS and CBMS-Home) compared to the mean of the two measures on the x-axis for day one scores. The 95% confidence intervals and the mean differences are represented as horizontal lines in the graph.

Test-retest reliability (i.e., comparison of the same measurements) and reliability between measurement occasions one week apart were assessed using intraclass correlation coefficients (ICCs). ICCs were calculated using a single measure, two-way mixed-effects model and absolute agreement. Interpretation of the ICC was according to the following standards: poor (< 0.50), moderate (0.50 to 0.75), good (0.75 to 0.90), and excellent (> 0.90) (Koo & Li, 2016). Standard error of measurement (SEM) and minimal detectable change (MDC) were determined to help researchers and clinicians interpret data (Donoghue & Stokes, 2009). SEM was determined by calculating SD × √ (1-ICC) and MDC_{95} was calculated by SEM × 1.96 × √2 at 95% confidence interval (Chou et al., 2006; Donoghue & Stokes, 2009; Mousavi et al., 2020). Internal consistency of the CBMS and CBMS-Home was assessed using Cronbach's alpha. Values higher than 0.70 indicated satisfactory level of internal consistency (Bland & Altman, 1997).

5.3.5.4 Sample size

A sample size of 50 participants was determined to have 80% power (alpha of 0.05) to detect a coefficient of determination (R^2) of 0.15 based on regression (correlation) analysis using G*Power (Faul et al., 2007).

5.4 Role of the funding source

This study was supported by the Curtin University Higher Degree by Research fund. The author's PhD studies were sponsored by Singapore Institute of Technology. The funders played no role in the design, conduct and reporting of this research.

5.5 Results

Fifty-five participants with a mean age of 77.2 (6.0) years completed the study. The average time between the first and second assessment of data collection was 7.4 (2.9) days and a median of 7 (5 – 28) days. One participant was assessed later because reassessment could only be performed after she recovered from lower limb edema. Most participants were females (74.5%), 89.1% took at least one medication prescribed by the doctor and 92.7% had at least one health issue. Participant demographics are shown in Table 5.1.

Table 5.1. Characteristics of participants

Variable	Participants (n = 55)
Age (years) M(SD)	77.2 (6.0)
Sex [male n (%): female n (%)]	14 (25.5): 41 (74.5)
Height (cm) M (SD)	166.2 (10.8)
Weight (kg) M (SD)	72.2 (14.3)
Education n (%)	
High school	29 (52.7)
Higher education (University and others)	26 (47.3)
Self-rated general health n (%)	
Poor	0 (0)
Fair	2 (3.6)
Good	23 (41.8)
Very good	22 (40.0)
Excellent	8 (14.5)
Aids n (%)	
Visual aids (spectacles)	51 (92.7)
Hearing aids	12 (21.8)
Health issues n (%)	51 (92.7)
Cardiac	8 (14.5)
Diabetes	9 (16.4)
Gastrointestinal	5 (9.1)
Glaucoma	2 (3.6)
Hyperlipidemia	9 (16.4)
Hypertension	23 (41.8)
Hypo/hyperthyroidism	10 (18.2)
Musculoskeletal	9 (16.4)
Mental health	2 (3.6)
Neurology (Parkinson's disease, stroke, and polio)	4 (7.3)
Osteoarthritis	13 (23.6)
Osteoporosis and osteopenia	14 (25.5)
Respiratory	4 (7.3)
Sleep apnea	3 (5.5)
Others (Anemia, allergy, neuritis, skin problems, polymyalgia, hernia, lymphedema)	13 (23.6)
Joint replacements n (%)	
Hip	2 (3.6)
Knee	6 (10.9)
Prescribed medications n (%)	49 (89.1)
$\geq$ 4 medications	26 (47.3)
Falls in the last year n (%)	15 (27.3)
CBMS scores (M (SD) (Total score: 96))	
No falls in the preceding year	56.5 (13.4)
Falls in the preceding year	41.3 (17.5)
CBMS-Home scores (M (SD) (Total score: 90))	
No falls in the preceding year	52.2 (11.5)
Falls in the preceding year	39.3 (15.2)

Note. Values are M = mean; SD = standard deviation; n (%) = number of participants (percentage); CBMS = Community Balance and Mobility Scale; CBMS-Home = Community Balance and Mobility Scale-Home.

5.5.1 Missing data

All participants completed the first assessment. All participants also returned for the second assessment, although two (3.6%) participants declined to perform up to two of the items during the second assessment. The items were recorded as missing data and pairwise deletion (Kang, 2013) was used during analysis.

5.5.2 Validity of CBMS-Home

The correlation matrix of CBMS and CBMS-Home showed that cross-correlations between all items were in the range of 0.3 – 0.9. The PCA identified three components with eigenvalues exceeding one, which accounted for 68.6% of the total variance (i.e., Component 1: 52.4%, Component 2: 9.4%, Component 3: 6.8%) for CBMS and 67.5% of the total variance (i.e., Component 1: 51.4%, Component 2: 9.3%, Component 3: 6.8%) for CBMS-Home.

These three components may be considered to represent balance performance (component 1), coordination performance (component 2) and muscle performance (component 3). Although all items had a major loading on one of the three components, five items (i.e., 'walk, look left, carry', 'walk, look right, carry', 'tandem walk', 'lateral dodge' and 'forward to backward walk') of the (CBMS) and six items (i.e., 'unilateral stance right leg', 'modified run with controlled stop', 'tandem walk', 'modified walk, look left, carry', 'modified forward to backward walk' and 'lateral dodge') of the (CBMS-Home) had a loading of higher than 0.3 on other component(s) (see Table 5.2).

Table 5.2. Pattern matrix

Accounting for CBMS: 68.6% (Component 1: 52.4%, Component 2: 9.4%, Component 3: 6.8%) and CBMS-Home: 67.5% (Component 1: 51.4%, Component 2: 9.3%, Component 3: 6.8%) of total variance using oblique rotation (i.e., Promax rotation)

CBMS				**CBMS-Home**			
Item	**Pattern coefficients**			**Item**	**Pattern coefficients**		
	Component 1	**Component 2**	**Component 3**		**Component 1**	**Component 2**	**Component 3**
Left lateral foot scoot	**0.863**			Left lateral foot scoot	**0.888**		
Right lateral foot scoot	**0.767**			Right lateral foot scoot	**0.815**		
Unilateral stance left leg	**0.732**			Left hop forward	**0.721**		
Left hop forward	**0.732**			Unilateral stance left leg	**0.709**		
180° tandem pivot	**0.709**			Right hop forward	**0.686**		
Run with controlled stop	**0.676**			180° tandem pivot	**0.605**		
Right hop forward	**0.636**			Unilateral stance right leg	**0.517**	0.346	
Unilateral stance right leg	**0.511**			Modified run with controlled stop	**0.371**		0.305
Walk, look to the right		**0.993**		Modified walk, look to the right		**1.018**	
Walk, look to the left		**0.910**		Modified walk, look to the left		**0.891**	
Walk, look right, carry		**0.733**	0.325	Modified walk, look right, carry		**0.761**	
Walk, look left, carry		**0.724**	0.365	Tandem walk	0.438	**0.648**	-0.386
Crouch and walk		**0.673**		Modified walk, look left, carry		**0.618**	0.362
Tandem walk	0.468	**0.651**	-0.437	Crouch and walk		**0.594**	
Step ups with right leg			**0.927**	Step ups with right leg			**0.967**
Step ups with left leg			**0.926**	Step ups with left leg			**0.966**
Descending stairs			**0.733**	Modified forward to backward walk	0.307		**0.588**
Lateral dodge		0.420	**0.429**	Lateral dodge		0.372	**0.513**
Forward to backward walk	0.307		**0.371**				

Note. CBMS = Community Balance and Mobility Scale; CBMS-Home = Community Balance and Mobility Scale-Home.

Coefficient values less than 0.30 have been removed from the table. Coefficient values in **bold** represent the **strongest** loading of the component.

There were no cross loadings >0.3 for the items most strongly loading onto each of the components – cross loadings mainly occurred on a small number of items with lower loadings on the three components. Cronbach's alpha for each individual component (i.e., balance, coordination, and muscle performance) of CBMS (0.90, 0.91, 0.81) and CBMS-Home (0.88, 0.90, 0.90) were high. There was a moderate positive correlation (r = 0.56 – 0.59) between the three components for CBMS and CBMS-Home.

5.5.3 Differences between CBMS and CBMS-Home scores

The paired t-test on day one demonstrated that CBMS-Home (M=54.1% (15.3)) was similar to CBMS (M = 54.5% (16.7)), (t (54) = -1.1, *p* = .293 (two tailed)). The mean difference between methods was 0.47 with a 95% confidence interval of -.41 to 1.35, and the eta squared statistic was 0.02 (small effect size).

5.5.4 Criterion validity

The Spearman's rank order correlation coefficient (ρ) revealed a moderate relationship between CBMS and CBMS-Home and ST, and a low relationship with FRT (see Table 5.3).

5.5.5 Ceiling and floor effects

The distribution scores of CBMS (minimum = 0; maximum = 80) and CBMS-Home (minimum = 0; maximum = 73) extended across the range of the scale on day one. One participant (1.8%) achieved the lowest score of zero and none of the participants achieved the highest score (see Table 5.3). There were no ceiling or floor effects.

Table 5.3. Score characteristics, criterion validity and internal consistency of CBMS and CBMS-Home

Assessment	**Mean (SD)**		**Floor effect***	**Ceiling effect***	**Cronbach's α***	**Functional Reach Test***			**Step Test ***		
	Day 1 (n=55)	**Day 2 (n=53)**				ρ	**95% CI**	***P***	ρ	**95% CI**	***P***
CBMS (0-96 points)	52.3 (16.0)	54.6 (17.1)	1.8%	0%	0.93	0.37	0.12 – 0.58	.005	0.64	0.45 – 0.77	< .001
CBMS (%)	54.5 (16.7)	56.9 (17.8)									
CBMS-Home (0-90 points)	48.7 (13.7)	50.8 (14.3)	1.8%	0%	0.94	0.39	0.14 – 0.59	.003	0.63	0.44 – 0.77	< .001
CBMS-Home (%)	54.1 (15.3)	56.5 (15.9)									

Note. SD=standard deviation; n = number of participants, floor and ceiling effects; Cronbach's α = Cronbach's alpha; ρ = Spearman correlation coefficient; CI = confidence interval; CBMS = Community Balance and Mobility Scale; CBMS-Home = Community Balance and Mobility Scale-Home; *P* = significance; *values reported for first day of assessment.

5.5.6 Reliability

When comparing individual items using the weighted Kappa statistic, moderate to almost perfect agreement was found between CBMS and modified CBMS items (K_W = 0.45 to 0.84; $p < .001$) on day 1 (inter-agreement). Cross comparisons of CBMS conducted between two separate days found varied agreements within the items ranging from fair to almost perfect agreement (K_W = 0.32 to 0.86; $p < .001$). When comparing the CBMS-Home modified items between two separate days, fair to substantial agreement (K_W = 0.39 to 0.76; $p < .001$) was found within the items (see Table 5.4).

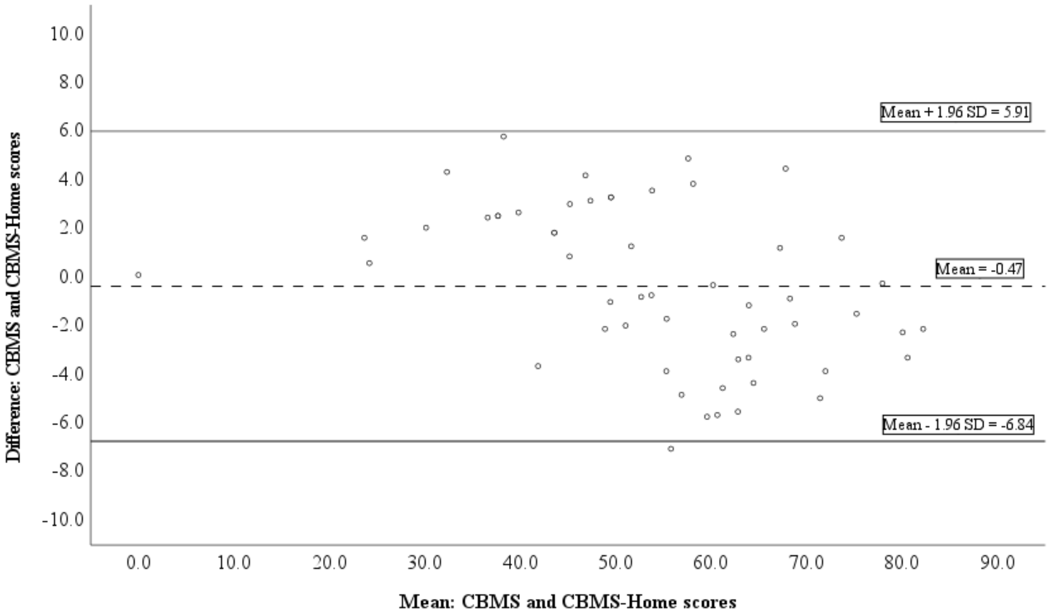
Figure 5.1 displays the mean and 95% limits of agreement (LOA) in the Bland-Altman plot analyses. The Bland-Altman analyses revealed an acceptable agreement between CBMS and CBMS-Home (LOA = -6.8% to 5.9%). Ninety eight percent of the values fell within the limits of agreement (95% confidence interval). The plots demonstrated scatter above and below the mean difference, which suggests random variability of the balance and mobility scores.

Table 5.4. Inter- and intra-agreement between and within items in CBMS and modified items in CBMS

Items	Inter-agreement (n = 55)		Intra-agreement (n = 53)		Intra-agreement (n = 53)	
	CBMS and modified items of CBMS conducted on day one		**CBMS conducted on two separate days**		**Modified items of CBMS conducted on two separate days**	
	K_W [95% CI]	**Agreement strength**	**K_W [95% CI]**	**Agreement strength**	**K_W [95% CI]**	**Agreement strength**
Unilateral stance L	-	-	0.57 [0.43, 0.70]	Moderate	-	-
Unilateral stance R	-	-	0.41 [0.25, 0.57]	Moderate	-	-
Tandem walk	-	-	0.32 [0.06, 0.57]	Fair	-	-
180° tandem pivot	-	-	0.70 [0.54, 0.85]	Substantial	-	-
L lateral scoot	-	-	0.48 [0.33, 0.64]	Moderate	-	-
R lateral scoot	-	-	0.61 [0.48, 0.75]	Substantial	-	-
L hop forward	-	-	0.73 [0.61, 0.85]	Substantial	-	-
R hop forward	-	-	0.71 [0.58, 0.85]	Substantial	-	-
Crouch and walk	-	-	0.35 [0.14, 0.57]	Fair	-	-
Lateral dodge	-	-	0.64 [0.42, 0.85]	Substantial	-	-
Walk and look to the L	0.76 [0.56, 0.95]	Substantial	0.76 [0.58, 0.94]	Substantial	0.76 [0.56, 0.95]	Substantial
Walk and look to the R	0.82 [0.65, 1.00]	Almost perfect	0.56 [0.32, 0.81]	Moderate	0.66 [0.39, 0.93]	Substantial
Run with controlled stop	0.45 [0.28, 0.63]	Moderate	0.63 [0.47, 0.80]	Substantial	0.39 [0.18, 0.61]	Fair
Walk forward to backward	0.64 [0.48, 0.80]	Substantial	0.42 [0.26, 0.57]	Moderate	0.47 [0.31, 0.62]	Moderate
Walk, look L and carry	0.79 [0.62, 0.95]	Substantial	0.64 [0.44, 0.84]	Substantial	0.76 [0.60, 0.93]	Substantial
Walk, look R and carry	0.84 [0.71, 0.98]	Almost perfect	0.60 [0.38, 0.82]	Moderate	0.75 [0.55, 0.94]	Substantial
Step ups with L leg	-	-	0.70 [0.56, 0.84]	Substantial	-	-
Step ups with R leg	-	-	0.72 [0.59, 0.84]	Substantial	-	-
Descending stairs	-	-	0.86 [0.73, 0.98]	Almost perfect	-	-

Note. CBMS = Community Balance and Mobility Scale; n = number of participants; K_W = weighted kappa; CI = confidence interval; L = Left; R = Right, K_W values: < 0.00: poor, 0.00 to 0.20: slight, 0.21 to 0.40: fair, 0.41 to 0.60: moderate, 0.61 to 0.80: substantial and 0.81 to 1.00: almost perfect (Landis & Koch, 1977); K_W values were significant at $p < .001$.

Figure 5.1. Bland-Altman plot demonstrating scores (converted to percentage) for CBMS and CBMS-Home.



Strong internal consistency was found for CBMS (Cronbach's α = 0.93) and CBMS-Home (Cronbach's α = 0.94) (see Table 5.5). Cronbach's alpha was examined with removal of each assessment item, and in all cases remained high (>0.9), which may indicate item redundancy. The test-retest reliability (between days) was excellent (ICC ranged from 0.95 to 0.96, $p < .001$). The SEM results were 3.46 (CBMS) and 3.12 (CBMS-Home). The MDC_{95} was 9.6 for the CBMS and 8.7 for the CBMS-Home. The inter-method reliability (comparing results of CBMS and CBMS-Home on day one) between the two tools was excellent (ICC ranged from 0.94 to 0.98, $p < .001$).

Table 5.5. Test-retest reliability and inter-method reliability

Test-retest reliability (n = 53)				**Inter-method reliability on day one of assessment (n = 55)**			
Assessment	**ICC**	**95% CI**	***P***	**Assessment**	**ICC**	**95% CI**	***P***
CBMS on two separate days	0.96	0.84 – 0.98	<.001	CBMS and CBMS-Home	0.94	0.60 – 0.98	<.001
CBMS-Home on two separate days	0.95	0.80 – 0.98	<.001	CBMS and CBMS-Home (%)	0.98	0.97 – 0.99	<.001

Note. CBMS = Community Balance and Mobility Scale; CBMS-Home = Community Balance and Mobility Scale-Home; n = number of participants; ICC = Intraclass correlation coefficient; CI = Confidence interval; *P* = significance.

5.6 Discussion

This study is the first to modify the 13-item CBMS to enable this comprehensive balance and mobility assessment to be suitable to be conducted in the homes of older adults. The accuracy of the CBMS-Home was evaluated using multiple tests of reliability and validity. The study revealed that modifying four items and removing the item “descending stairs’ to create the CBMS-Home maintained its psychometric properties in evaluating balance and mobility of older adults.

The PCA evaluated the strength of correlations between individual scale items, and whether the overall assessment was unidimensional or involved multiple factors or domains. Results demonstrated that both the CBMS and CBMS-Home were comprised of three components, which may be interpreted as balance, coordination, and muscle performance factors. The CBMS and CBMS-Home measures balance and mobility performance of older adults. It could therefore be expected that balance contributed to the largest proportion of variance (i.e., 52.4% (CBMS) and 51.4% (CBMS-Home). The remaining two components (i.e., coordination and muscle performance) contributed to lesser proportions of variance. The strong internal consistency within the three components suggests that the items were measuring discrete balance and mobility performance. All items presented a major loading; however, cross loadings were observed across components for some items in CBMS and CBMS-Home. These items were retained because they provided important information that a physiotherapist would want to know during an assessment and reflected the multi-dimensionality of balance and mobility assessment during human performance. Results of a previous factor analysis also identified three factors, but interpreted / labeled these factors as strength (factor 1), mobility (factor 2), and balance (factor 3) for CBMS amongst a sample of older adults with knee osteoarthritis (Takacs, Krowchuk, Goldsmith, et al., 2017). The results differ in the interpretation of the sequence of the factors and naming of one factor, potentially due to the differences of the population recruited (i.e., the previous study (Takacs, Krowchuk, Goldsmith, et al., 2017) recruited older adults presenting with knee osteoarthritis and pain, and this current study recruited older adults presenting with a number of different medical conditions).

The variety of items assessed, and that the items of both the CBMS and CBMS-Home span across the spectrum of performance that may be expected for the target sample (older adults) as demonstrated by the lack of ceiling and floor effects in our study, and previous studies of the CBMS (Balasubramanian, 2015; Takacs et al., 2014) reinforce the usefulness of the CBMS and the new CBMS-Home. The lack of ceiling effect was maintained even with removal of what may be considered one of the more challenging items (descending stairs) in the CBMS-Home, indicating that the remaining items were sufficiently demanding to detect subtle balance impairments among this sample of generally well older adults. This is in contrast to some other commonly used assessment tools evaluating balance and mobility in older adults, such as the Berg Balance Scale, which has been shown to have ceiling effects (Godi et al., 2013; Schlenstedt et al., 2015). Lack of ceiling effects is particularly important when aiming to identify mild or early signs of balance or mobility impairment in older adults from a prevention perspective.

The amount of error associated with measurement is important to determine, to assist clinicians to identify whether observed change is real, or within what would be expected as measurement error. The values of the MDC_{95} were 9.6 and 8.7 for CBMS and CBMS-Home respectively, which were similar to the value obtained from a previous study on people with knee osteoarthritis using the CBMS (MDC_{95} = 9.4 points) (Takacs et al., 2014).

Low to moderate correlations were identified between CBMS-Home and CBMS and two commonly used tests of balance performance - FRT and ST. These two criterion tests each assess a single domain or aspect of balance, while the CBMS and CBMS-Home assess multiple domains of balance or mobility. Use of other multi-domain assessments such as Balance Evaluation Systems Test (BESTest) (Wang-Hsu & Smith, 2018) and Fullerton Advanced Balance Scale (Rose et al., 2006) for evaluation of criterion validity may have resulted in stronger levels of correlation for this analysis.

Reliability (i.e., consistency of measurement) is vital to ensure that the results of a measurement are reproducible and stable. Fair to almost perfect agreements was found for CBMS and fair to substantial agreements for CBMS-Home across two days. Higher agreements (i.e., moderate to almost perfect; Kappa = 0.62 to 0.94; $p < .001$) of CBMS were reported in a previous study (Weber et al., 2018). The method used in this previous study (scoring of CBMS while reviewing a video recording of participants' performance twice within the same session) may have contributed to the higher agreements reported. Our CBMS and CBMS-Home results indicate high levels of test-retest reliability. High levels of ICC emphasize that CBMS and CBMS-Home measurements are stable and assist physiotherapists to assess change in participants' performance over time. Cronbach's alpha evaluated the strength of the relationship of a set of items when grouped together. The strong internal consistency demonstrated by our results, and previous studies (Balasubramanian, 2015; Lee et al., 2016) indicated that CBMS-Home evaluated a similar construct of balance and mobility despite the removal of one item. The evidence of CBMS reviewed reinforced the findings of the previous work of CBMS. However, the high Cronbach's $\alpha > 0.90$, including when individual items were removed, indicate there may be some item redundancies, which may be an important issue for future CBMS-Home research. In summary, our current findings on the original CBMS support similar levels of measurement consistency for CBMS-Home (i.e., good agreements in Bland-Altman and weighted kappa and strong test-retest reliability between methods).

The results of our study indicate that CBMS-Home is valid and reliable. These findings for the new CBMS-Home provide a key step towards improving feasibility because the assessment tool can be administered in settings with a smaller space (i.e., four-meter track) and when stairs are not available. Even though the CBMS-Home has been modified to be able to be conducted within the homes of older adults, it does require some equipment for the physiotherapist to bring to ensure all items can be assessed. This includes having a single step for the item ‘step ups’, a target placed on a wall, several weights, a bean bag, a stopwatch and plastic grocery bags. These may be carried to and from assessments in a small case on wheels. During the performance of CBMS-Home and CBMS, no serious or adverse events were reported. Although participants were provided with rest between items whenever required, two participants did report musculoskeletal incidences (i.e., muscle soreness or pain in the joint) after the first assessment, which resolved with self-conservative management between assessment occasions.

5.7 Limitations

Several limitations need to be considered. Two of the items (i.e., ‘Walk and look’ and ‘walk, look and carry’) are similar in nature and were conducted in a fixed sequence, which may have influenced the performance of the item (i.e., quality and speed), because of repeated administration of very similar tasks. Therefore, when conducting assessments with the CBMS-Home, physiotherapists may consider randomizing the sequence of these items or record the score after a trial practice of each item. Ninety eight percent of the assessments were conducted on a carpeted floor, which may act as a resistance and may influence the ability of the participants to perform some items such as the ‘lateral foot scoot’. Floor surfaces of the available areas with sufficient length for assessment in people’s homes may vary, however, these should be able to be standardized between measurement occasions for individuals when comparing assessments over time. In addition, different footwear may influence the ability to perform some of the items, therefore efforts should be made to standardize footwear.

5.8 Conclusion

The results of this study revealed that CBMS-Home demonstrated good to very good outcomes for most measurement properties when compared with the original CBMS. CBMS-Home is more feasible in settings for physiotherapy assessment when there is limited space, and /or stairs are not available. This finding is important because CBMS-Home provides physiotherapists with an additional assessment tool that has strong validity and reliability to evaluate balance and mobility of older adults within their home. Also, older adults can enjoy the convenience of a physiotherapy assessment at home without dealing with factors such as weather and travel challenges that may impact their ability to attend a physiotherapy practice.

5.9 Ethics Approval

The study was approved by the Curtin University Human Research Ethics Committee (Approval Number: HRE2019-0735). All participants provided written informed consent prior to participation in the study.

Chapter 6 : Seniors Exercise Park program for older adults with mild balance dysfunction − A feasibility study

Chapter outline

Older adults with mild balance dysfunction may be at increased risk of falling and could benefit from an early exercise intervention. Seniors Exercise Parks could provide early intervention to improve balance performance or slow down the rate of further decline in balance for older adults with mild balance dysfunction. No studies have evaluated the feasibility, safety and effects of Seniors Exercise Park use in older adults with mild balance dysfunction. This chapter presents the findings of a study investigating the feasibility, safety, and effects of a gradually reduced supervised Seniors Exercise Park program progressing to independent training in older adults with mild balance dysfunction.

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6.1 Abstract

Purpose: To evaluate the feasibility of a multimodal exercise program conducted at a Seniors Exercise Park among older adults with mild balance dysfunction.

Method: Participants (aged ≥65 years) with mild balance dysfunction underwent 18 weeks of gradual reduction of supervised training followed by six weeks of independent training at the Seniors Exercise Park. Feasibility and safety were assessed at baseline, 18 and 24 weeks.

Results: Seventy-five participants expressed interest in the program. Of the 46 participants enrolled in the study, 36 (78.3%) completed the 18 week intervention, and 32 (69.6%) were followed-up at 24 weeks. The median adherence to supervised training was 90.9%, and independent practice was 26.3% (weeks 19 to 24). All the supervised training sessions were completed within 18 weeks. No falls, or adverse events occurred. All physical performance (e.g., balance, lower body strength, and mobility), psychosocial health outcomes (e.g., mental well-being) and quality of life improved significantly at 18 and 24 weeks.

Conclusions: This initially supervised Seniors Exercise Park program, which progressed to independent practice, is feasible, safe, and improved health outcomes in older adults with mild balance dysfunction. Strategies are needed to improve adherence to independent practice and minimise dropouts.

Implications for rehabilitation: Gradually reduced supervision in a Seniors Exercise Park program progressing to independent practice is feasible and safe for older adults with mild balance dysfunction. Seniors Exercise Parks can assist older adults with mild balance dysfunction to improve their balance, lower body strength, mobility, and psychosocial health. There is a need for more Seniors Exercise Parks in community

parks to enable greater access to this novel exercise approach by older people, including those with mild balance dysfunction.

6.2 Introduction

Participation in physical activity or exercise is important for maintaining health and physical function (Piercy et al., 2018; Warburton & Bredin, 2017; Whitehead & Blaxton, 2017). Current Australian physical activity guidelines recommend that older adults participate in at least 30 minutes of moderate intensity physical activity most days per week or daily and to perform multi-modal activities such as balance, strength, flexibility, and aerobic training (Australian Institute of Health and Welfare, 2020; Sims et al., 2010). However, only 26.1% of older adults meet the physical activity recommendations (Australian Institute of Health and Welfare, 2020), and a lower percentage engage in strength (Australian Institute of Health and Welfare, 2020) and balance activities (Merom, Pye, et al., 2012). To encourage an increase in physical activity among older adults, novel activities or equipment should be considered.

Outdoor exercise equipment installed in parks could provide novel physical activity opportunities for older adults. Improved physical performance have been reported following supervised programs using outdoor exercise equipment with adults (Nguyen & Raney, 2014) and with older adults (Ng, Hill, Levinger, et al., 2021). A Seniors Exercise Park is an outdoor multi-modal set of equipment built specifically for older adults (Sales et al., 2017). A unique feature of the Seniors Exercise Park is the inclusion of safe balance training equipment, which is not available in many other types of outdoor exercise equipment (Ng, Hill, Levinger, et al., 2021). Limited studies have demonstrated that independent, community ambulant older adults improved their physical activity levels (Levinger et al., 2020) and physical performance after participating in Seniors Exercise Park training with the supervision of a health professional (Levinger et al., 2020; Sales et al., 2017). However, these successful programs have used twice-weekly supervision by health professionals for 18 weeks

(Sales et al., 2017) and 36 weeks (i.e., 12 weeks during the intervention phase and another 24 weeks where participants could choose to attend supervised sessions during the maintenance phase) (Levinger et al., 2020) respectively, which may have placed specific time demands on the participants and was also resource intensive in terms of costs and sustainability. In addition, higher functioning older adults appeared to be recruited in these previous studies, as the primary outcome measure (i.e., Balance Outcome Measure for Elderly Rehabilitation test) demonstrated ceiling effects (Sales et al., 2017) and the mean number of steps completed in 15 seconds using the Step Test (Levinger et al., 2020) were higher than the mean reported for healthy community-dwelling older adults (Hill, Bernhardt, et al., 1996; Nolan et al., 2010).

A group of older adults at risk of future falls and mobility decline are those presenting with mild balance dysfunction (Beauchamp, 2020). A number of definitions of mild balance dysfunction have been reported (Nnodim et al., 2006; Rezaei et al., 2021; Sinaei et al., 2016; Williams et al., 2015; Yang et al., 2012). For the purpose of this study, criteria used to classify mild balance dysfunction reported previously by Yang et al. (2012) were used, and included those who were community ambulant, did not use more than a single-point walking stick for mobility, had experienced no more than one fall in the past 12 months, and scored outside normative scores on either or both the Functional Reach Test or Step Test (see Methods) (Williams et al., 2015). Older adults with mild balance dysfunction may not realise they have balance issues, nor consult a health professional about their balance and mobility concerns, as they may attribute their unsteadiness to the ageing process or are unsure whether their balance performance is impaired or not (Williams et al., 2015; Yang et al., 2011).

It is possible for older adults with mild balance dysfunction to improve their physical performance, as was found in a home-based balance, walking, and strength training program (Williams et al., 2015; Yang et al., 2012).

However, it is currently unknown whether older adults with mild balance dysfunction can safely use an outdoor Seniors Exercise Park to improve physical performance. Therefore, this study aimed to evaluate the feasibility (using the domains of feasibility reported by Bowen et al. (2009), including demand, implementation, practicality (including safety), efficacy testing, adaptation, and acceptability) of an 18 week gradual reduction in supervision to independent use of the Seniors Exercise Park training program, and an additional six weeks (i.e., weeks 19 to 24) of independent Seniors Exercise Park practice in older adults with mild balance dysfunction.

6.3 Methods

6.3.1 Study design

This study used a quasi-experimental single group pre-post study design. Assessments were conducted at baseline and after 18 and 24 weeks participation in the Seniors Exercise Park intervention. Ethical approval was obtained from Curtin University Human Research Ethics Committee (Approval Number: HRE2019-0734).

6.3.2 Inclusion criteria

The inclusion criteria were: adults (aged 65 years or older) who did not meet the Australian physical activity guidelines of 30 minutes of moderate physical activity on most days/daily; walked independently indoors, and/or, outdoors with no more than a walking stick (Williams et al., 2015); had no more than one fall in the past 12 months (Williams et al., 2015); and/or expressed concerns about balance (Williams et al., 2015); were able to speak, read and understand English; were considered suitable to participate in exercise using the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) (Warburton, Bredin, et al., 2011) or received clearance to participate from a General Practitioner; and had no cognitive impairment (Abbreviated Mental Test Score >7/10) (Jackson et al., 2013). A further inclusion criterion was presence of mild balance dysfunction, defined using previously reported cut-off scores for one or both of the following tests: the Functional Reach Test or Step Test scores being below the cut-off scores for their age (i.e., 65-75 years, Functional Reach Test <29 cm and Step Test <17 steps / 15 seconds respectively; and >75 years, Functional Reach Test <27 cm and Step Test <15 steps / 15 seconds respectively) (Williams et al., 2015).

6.3.3 Recruitment and data collection

Participants were recruited by advertisement at a retirement village, local community council, through word of mouth and from a research volunteer database. Older adults who were interested in participating in the study were screened by telephone to determine their eligibility. If they met the initial inclusion criteria obtained over the phone, an appointment was made to complete the additional inclusion criteria, and if eligible, gain written consent prior to completing the baseline assessment. Baseline assessment included participants completing a questionnaire about their age, health, medications, and history of falls (defined as "an event which results in a person coming to rest inadvertently on the ground or floor or other lower level" (World Health Organization, 2021, p. 1)) during the past 12 months. Participants were then asked to complete standardised questionnaires and outcome measures (described below). All outcome measures were conducted by a qualified physiotherapist. After the baseline assessment, the participant could choose to attend an orientation session of up to 30 minutes at the Seniors Exercise Park on the same or another day. The purpose of the orientation was to determine the most appropriate starting level of exercises for each participant, based on both the assessment findings and observed performance on the exercise equipment. The same standardised questionnaires and outcome measures were repeated after 18 and 24 weeks by the same physiotherapist who conducted the baseline assessment and supervised the intervention.

6.3.4 Feasibility

The feasibility of the Seniors Exercise Park program was evaluated across six domains: demand, implementation, practicality (including safety), efficacy testing, adaptation, and acceptability, using a framework previously reported by Bowen et al. (2009).

6.3.4.1 Demand

Demand for the program included reporting the number of participants who enquired about the program, the number of participants recruited to the program and the number of participants who completed the program at 18 and 24 weeks.

6.3.4.2 Implementation

Implementation evaluated whether the intervention could be executed as planned. In addition, the number of sessions that were cancelled because it was deemed unsafe to exercise (e.g., the potential for falls due to wet/slippery surfaces or potential heat stroke) during extreme weather conditions (e.g., raining or hot weather). Where possible, classes were replaced on another day when the sessions were cancelled due to extreme weather conditions.

The number and proportion of scheduled sessions attended by the participants (i.e., adherence) to supervised sessions and the reasons for absence from these sessions were recorded. Adherence to independent practice was evaluated by the number and proportion of sessions participants exercised at the Seniors Exercise Park on their own (i.e., total sessions = 14 (baseline to week 18) and 12 (week 19 to 24)). Like the supervised sessions, participants were encouraged to participate for 60 minutes in the independent unsupervised practice sessions. Participants recorded their independent practice using an exercise diary collected by the researcher at the 24 week assessment. If the participant could not visit the Seniors Exercise Park because of COVID-19 lockdowns or following local government regulations due to COVID-19, the total number of independent sessions were adjusted proportionately (Levinger, Dunn, et al., 2021).

6.3.4.3 Practicality (including safety)

Practicality described whether the participants were able to perform the exercises at the Seniors Exercise Park with supervision and also on their own. In addition, adverse events occurring during the program were also evaluated, these included (i) any emergency events (e.g., angina, cardiac arrest) or any falls; and (ii) any pain or muscle soreness related to the intervention (i.e., across the 24 weeks).

6.3.4.4 Efficacy testing

For this domain of Bowen's feasibility framework, the program's effects and whether the effects were maintained after the completion of the supervised intervention were evaluated (Bowen et al., 2009). Various physical performance, psychosocial outcomes, and quality of life measures were evaluated at baseline, week 18 and week 24 to determine whether there were any effects at 18 weeks and if the effects were maintained up to 24 weeks.

6.3.4.4.1 Physical performance measures

Participants were given the option of having the assessments undertaken at their home or at a central venue. The Community Balance and Mobility Scale-Home (CBMS-

Home) was used to assess the balance and mobility of participants, which are important for maintaining functional independence in the community (Ng, Hill, Jacques, et al., 2021). The CBMS-Home (12-item scale) is a modified version of the original CBMS (13-item), adapted to enable assessments to be undertaken in typical homes of older people. The CBMS-Home is a validated and reliable tool, and includes some challenging tasks such as running, hopping on one leg and lateral scoot on one leg, and initial research indicates a lack of ceiling effect in older people (Ng, Hill, Jacques, et al., 2021). Each item is scored on a scale of zero to five, with zero indicating unable to perform the task and five indicating the task was completed within a certain distance, duration, and with good quality movement (Howe et al., 2011; Ng, Hill, Jacques, et al., 2021). The description of the tasks and scoring has been described previously (Ng, Hill, Jacques, et al., 2021). The highest total score for CBMS-Home is 90 points, and the test takes on average 25 minutes to complete.

The Five Times Sit to Stand test was used to measure lower body strength (Whitney et al., 2005). Participants were instructed to stand up and sit down quickly from a chair (i.e., height of 43 cm) five times with their arms folded across their chest (Whitney et al., 2005).

The Four Square Step Test was used to assess participants' dynamic balance, by timing their ability to step over low objects in multiple directions (Dite & Temple, 2002). Fast gait speed was used to measure walking performance (Artaud et al., 2015; Bohannon & Wang, 2019). Participants commenced with a static start and were instructed to walk quickly for four meters until they crossed the finish line, with the time recorded using a hand-held stop watch (Bohannon & Wang, 2019).

The Physical Activity Scale for the Elderly (PASE) questionnaire was used to evaluate participants' physical activity levels over the previous seven days (New England

Research Institutes, 1991; Washburn et al., 1993). Examples of activities assessed included walking, exercise, gardening, and housework. Participants' responses to the items were calculated from frequency values and weights for each activity (New England Research Institutes, 1991; Washburn et al., 1993). Scores range from zero to 400 (New England Research Institutes, 1991; Washburn et al., 1993).

6.3.4.4.2 Psychosocial measures

The WHO-5 Well-Being Index consists of five questions that assess mental well-being (Topp et al., 2015). The total raw score for each participant ranged from zero to 25 and was multiplied by four to give a percentage (Topp et al., 2015). Higher scores suggest better mental well-being.

The UCLA Three-Item Loneliness Scale measured perceived loneliness (Hughes et al., 2004). The scale consists of three questions, and participants rated each on a three-point scale. Total scores ranged from three to nine. Higher scores indicate greater feelings of loneliness (Hughes et al., 2004).

The Self-Efficacy Scale for Exercise consists of nine items related to participants' efficacy to continue exercising when encountering barriers to exercise (Resnick & Jenkins, 2000). Total scores range from zero to 90. Higher scores indicate higher confidence in the ability to participate in exercise (Resnick & Jenkins, 2000).

The Modified Falls Efficacy Scale measures participants' level of confidence of participants performing 14 tasks without overbalancing, with responses for each task rated on a scale from zero (not confident) to 10 (completely confident) (Hill, Schwarz, et al., 1996). The scores were averaged across the 14 items for each participant (total score range zero to 10), with higher scores suggesting higher confidence.

The EQ-5D-5L consists of two components measuring the quality of life of an individual (Janssen et al., 2013). The first component measures health in five dimensions (self-care, mobility, pain/discomfort, anxiety/depression, and usual activities) with five levels of response ranging from no problems to extreme problems/unable to do (Janssen et al., 2013). The responses to the dimensions were recalculated to a single index value ranging from zero (i.e., death) to one (i.e., perfect health) (Janssen et al., 2013). The Australian value set was used (Norman et al., 2013). The second component used a visual analogue scale for the participant to rate their own health (range from zero to 100), with higher scores suggesting better health.

6.3.4.5 Adaptation

This area describes changes made to the program content to suit the needs and context of older adults with mild balance dysfunction. Each participants' program was individualised and depended on their levels of physical fitness (i.e., balance, strength, endurance, flexibility). All programs were increased over time as each participant improved their ability to complete the exercises included in the intervention.

6.3.4.6 Acceptability

This area assessed the satisfaction of the program by the participants. The perceptions of the participants about the program were explored and reported in a separate study (under review).

6.3.5 Seniors Exercise Park intervention program

The intervention was delivered by a qualified physiotherapist using the Seniors Exercise Park equipment (Lappset Group Ltd, Lark Industries Australia) at a retirement village in Perth, Western Australia (see Figure 6.1). The Seniors Exercise Park was in an open access area of the retirement village, and was available for use at no cost during the physiotherapist supervised sessions and independent use. Participants lived nearby the Seniors Exercise Park within the retirement village (i.e., a 15-hectare area) (SwanCare, 2022).

Figure 6.1. The Seniors Exercise Park in Perth, Western Australia

Alternative text = Photograph of outdoor exercise equipment built specifically for older adults located in Perth, Western Australia.

Participants underwent twice-weekly supervised sessions of one hour duration initially in a group. Each session consisted of five minutes warm up and cool down exercises and 50 minutes of circuit-based exercise using the equipment. A total of 22 supervised sessions were provided across 18 weeks (see Table 6.1), with supervised sessions becoming less frequent as the program progressed. The ratio of physiotherapist to participants per session was a maximum of 1:8. Exercises prescribed were adapted and modified from Sales et al. (2015).

Table 6.1. A gradual reduction of supervision for 18 weeks and independent unsupervised practice for six weeks

Week number 1-18																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨□	▨□	▨□	▨□	▨□	□▨	□□	▨□	□□	▨□	□□	▨▨

▨ Supervised sessions = 22 sessions □ Independent practice = 14 sessions

Week number 19-24					
1	2	3	4	5	6
□□	□□	□□	□□	□□	□□

□ Independent practice = 12 sessions

Modifications to Sales et al. (2015) included using a standard chair instead of a bench at the Seniors Exercise Park for sit to stand exercises, using cuffed ankle weights (i.e., 1 or 2kg) instead of elastic resistance bands for hip exercises, and the exercise stations used (i.e., participants alternated between two sets of exercises throughout the 18 weeks) (see Table 6.2).

Table 6.2. Seniors Exercise Park Stations throughout 18 weeks

Exercise stations for even numbered sessions	**Exercise stations for odd numbered sessions**
Pull-ups	Push-ups
Calf raises and finger steps	Shoulder arches
Gangway	Balance stool
Handroll	Balance beam
Ramp and net	Core twister
Snake pipe – big wave	Snake pipe – small wave
Sit to stand	Step ups
Stairs	Taps on platform
Hip extension	Hip abduction

Note. Even numbered sessions: Session number 2,4,6,8,10,12,14,16,18,20,22.
Odd numbered sessions: Session number 1,3,5,7,9,11,13,15,17,19,21.

Participants performed the prescribed repetition of exercises at each station until they completed all stations in the circuit. The repetition of exercises was prescribed according to the ability of the participant, and these were increased as the participants' performance improved. One repetition for each piece of exercise equipment was counted in the following manner (i) when the participant walked forward and backward for the full distance on the gangway, balance beam, ramp and/or net; (ii) rocking side to side to the left and right on the balance stool; (iii) twisting side to side to the left and right on the core twister; (iv) moving the ring across one end to the other on the snake pipe, small wave and big wave; (v) climbing up and down the stairs once; (vi) turning one full cycle on the handroll; (vii) doing pull-ups, push-ups, sit to stand and calf raises; and (viii) tapping on the platform and performing hip extension and abduction once on each leg respectively. Participants rested between exercise stations as required.

In the final three supervised sessions of the 18 week intervention period (for each group), up to 30 minutes of each session was used to prepare participants for independent Seniors Exercise Park practice. Resources (e.g., handouts, cuffed ankle weights) were provided to support this transition. During the six week follow-up period (i.e., week 19-24), participants continued independent, unsupervised Seniors Exercise Park practice. They were informed about occasional times when the physiotherapist would be present to assist them with any difficulties encountered during independent Seniors Exercise Park use. Participants chose whether to attend these sessions or not.

6.3.6 Procedures required during COVID-19 pandemic

This study commenced during the COVID-19 pandemic. Measures were taken to minimise the chance of transmission of COVID-19 during the Seniors Exercise Park intervention. Participants maintained a physical distance of at least 1.5 metres between each other while completing each exercise. In addition, exercise stations were cleaned before and after each session, and participants sanitised their hands before, during and after the training sessions. Participants wore facemasks at certain times during the intervention when it was mandatory, while following government regulations.

6.3.7 Sample size

Recommended sample sizes for feasibility studies vary, ranging from 10 to 300 participants (median = 36 participants) (Billingham et al., 2013). For the efficacy testing component, the modified CBMS was a priori selected as the primary outcome. A power analysis was undertaken using data from the original 13-item Community Balance and Mobility Scale (CBMS) because there were no previous intervention data using the 12-item CBMS-Home at the time the study commenced. A sample size of n = 20 was calculated to have 80% power (alpha of 0.05), in a repeated measures model over three time points, to detect a 10% within group change in mean CBMS score (Effect size = 0.3, Mean difference = 5 points, Standard deviation = 16.5 which accounted for 10% variability based on the results of a previous study) (Takacs, Krowchuk, Garland, et al., 2017). To account for an anticipated attrition of 20% at 18 weeks and a further 10% at 24 weeks, a minimum of 29 participants needed to be recruited. G*power 3.1.9.4 software (Faul et al., 2007) was used to calculate the sample size.

6.3.8 Statistical analyses

Data distributions were checked using Shapiro-Wilk tests and graphically. The data were analysed using STATA version 17.0, 2021 (StataCorp., 2021). Participant demographics and feasibility data were reported as mean (standard deviation) or median (interquartile range). Differences between those who completed the 18 weeks of gradually reducing supervised Seniors Exercise Park intervention and those who dropped out by this time point were compared using univariate analysis: Fisher's exact test for categorical data (Kim, 2017), and independent samples t-test and Mann-Whitney U test for continuous data as appropriate for data distribution (Cleophas & Zwinderman, 2016).

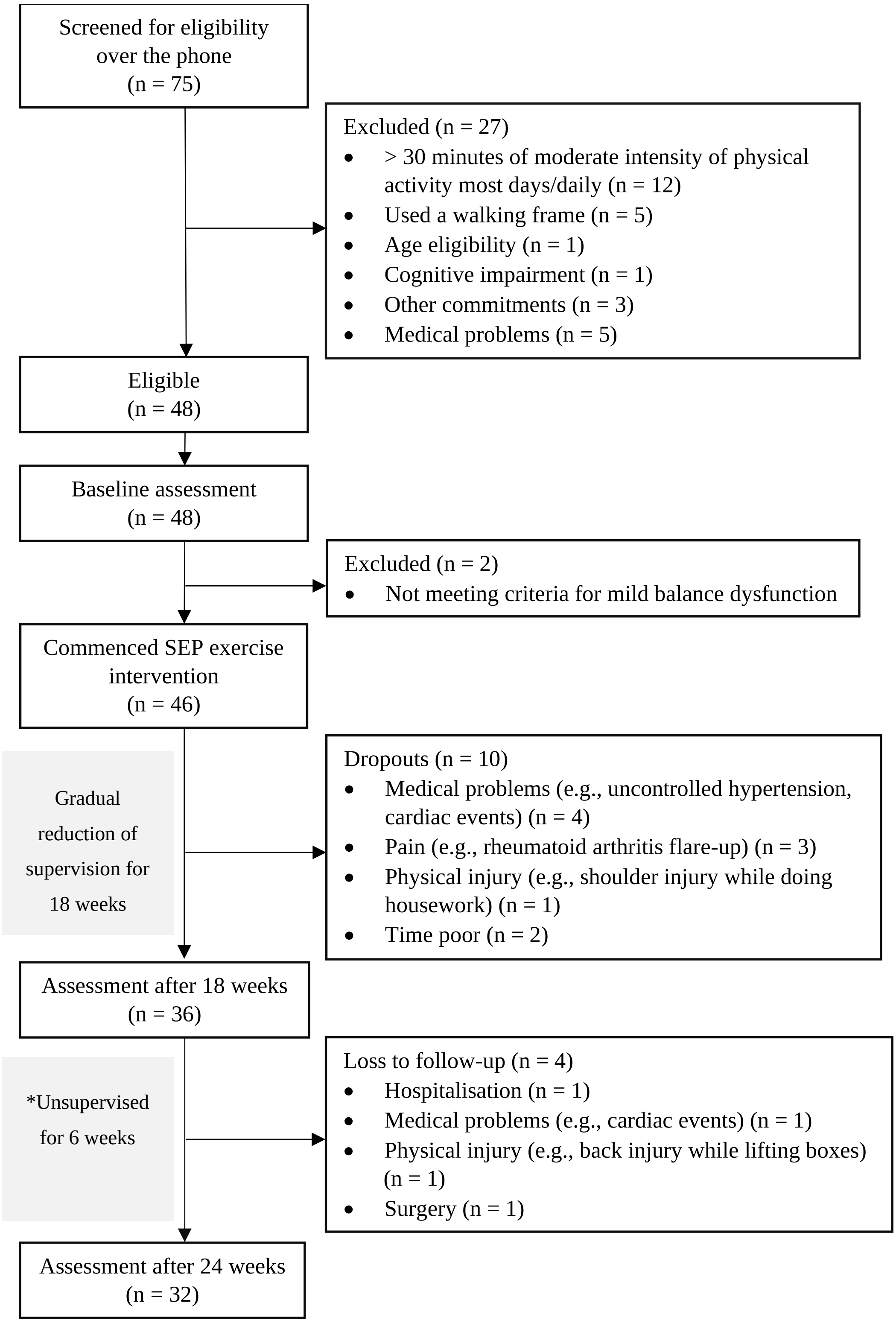
For the efficacy testing component, generalised linear mixed models, utilising links or transformations appropriate to outcome data distributions, and mixed effects tobit models for censored outcomes, were used to analyse all repeated assessments (i.e., baseline, 18 weeks, 24 weeks). Model fit was assessed by graphically checking normality of residuals. As mixed effects models utilise maximum likelihood estimation methods to estimate parameters, cases with missing data points were not excluded from any modelling (Chakraborty & Hong, 2009; Krueger & Tian, 2004). Results are reported as predicted marginal means, estimated mean differences, effect sizes, and 95% confidence intervals. Differences were based on changes from baseline to 18 weeks, 18 weeks to 24 weeks, and baseline to 24 weeks. Statistical significance was set at $p < .05$. Effect sizes (i.e., Cohen's *d*) were calculated to evaluate the standardised magnitude of change following intervention and were classified as small ($d = 0.20$ - 0.49), moderate ($d = 0.50$ - 0.79) or large ($d \geq 0.80$) (Cohen, 2013).

6.4 Results

6.4.1 Participants and demand

Recruitment commenced in June 2020 and data collection was completed by September 2021. There were 75 people who expressed an interest in the program (see Figure 6.2).

Figure 6.2. Flow diagram of recruitment and attrition



Note. SEP = Seniors Exercise Park.

* = Participants have the option to meet the physiotherapist at the Seniors Exercise Park if they have any issues with their exercises.

Alternative text = Flow diagram of recruitment and attrition of the Seniors Exercise Park program at baseline, after 18 and 24 weeks.

Twenty-seven people were ineligible or were not able to commit to the program. Forty-six participants with mild balance dysfunction were recruited from a retirement village (no participants were recruited from other community avenues). The percentage of participants who completed the 18 week intervention was 78.3% (number of participants n = 36) and 69.6% (n = 32) of participants were re-assessed at 24 weeks. The total number of dropouts was 14 (30.4%) across the 24 weeks. Reasons for withdrawing (i.e., dropouts) included medical problems (e.g., uncontrolled hypertension), pain (e.g., rheumatoid arthritis flare-up), hospitalisation (e.g., angina) and physical injury (e.g., injured shoulder doing housework), and other commitments. Characteristics of the participants are reported in Table 6.3.

Most participants were females and had at least one medical condition. The most common medical condition among participants was hypertension. At baseline across the 11 main participant characteristics and the two physical performance tests used to determine presence of mild balance dysfunction (see Table 6.3), two were statistically significant between those who completed and those who did not complete the intervention. A greater proportion of those ceasing participation took four or more medications, and those ceasing participation scored lower in the Step Test. Participants completing the intervention and those ceasing participation in the intervention were similar ($p > .05$) on all other characteristics and measures at baseline.

Table 6.3. Participants' characteristics at baseline

Variable	Recruited n = 46
Age, mean ± SD	77.8 ± 6.0
Females, n (%)	41 (89.1)
Height (m), mean ± SD	1.6 ± 8.6
Weight (kg), mean ± SD	75.1 ± 15.1
BMI (kg/m^2), mean ± SD	28.1 ± 5.5
Falls, n (%)	6 (13)
Uses a walking stick, n (%)	5 (10.9)
Wears spectacles, n (%)	44 (95.7)
Medical conditions, n (%)	
Bladder, renal and gastrointestinal conditions	10 (21.7)
Cardiovascular conditions	12 (26.1)
Diabetes	7 (15.2)
Depression	2 (4.3)
Gout	2 (4.3)
Hearing impairments	14 (30.4)
Hyperlipidemia	12 (26.1)
Hypotension	1 (2.2)
Hypertension	30 (65.2)
Macular degeneration	3 (6.5)
Musculoskeletal conditions (e.g., bursitis, chronic backache, scoliosis, spondylitis)	15 (32.6)
Neurological conditions (e.g., Parkinson's disease and history of stroke)	2 (4.3)
Osteoporosis/Osteopenia	
Osteoarthritis	10 (21.7)
Respiratory conditions	10 (21.7)
Rheumatoid arthritis	10 (21.7)
Sleep apnoea	2 (4.3)
Other conditions (e.g., hypothyroid, eczema, Bowen's disease, CREST syndrome, lichen planus, sinusitis, Von Willebrand disease, schizoaffective disorder)	3 (6.5) 12 (26.1)
Joint replacement, n (%)	
Total knee replacement	6 (13)
Total hip replacement	6 (13)
Medication usage, n (%)	
Taking prescribed medications	44 (95.7)
Taking ≥ 4 medications	22 (47.8)
Step Test, mean ± SD	10.3 ± 2.3
Functional Reach Test (cm), median (IQR)	32.3 (29.8-34.0)

Note. CREST syndrome = Calcinosis, Raynaud's phenomenon, Esophageal dysfunction, Sclerodactyly, Telangiectasis syndrome; n = number of participants; % = percentage; IQR = interquartile range; SD = standard deviation.

6.4.2 Implementation

All of the a priori supervised training sessions were implemented within 18 weeks for all the participants. However, it must be noted that 22 (14.3%) sessions were cancelled due to extremes of weather (e.g., rain or extreme heat), but replaced within the 18 weeks. The median number of sessions attended was 20.0 (IQR = 17.5 - 21.0) and adherence was 90.9% (IQR = 79.5 - 95.5) during the supervised 18 week intervention. Reasons for missing sessions included medical appointments (n = 11), illness (n = 11), travel (n = 8), pre-existing pain (n = 3), pre-existing injury (n = 1), new injury (n = 2), eye surgery (n = 1), other commitments (n = 10) and other reasons (n = 3). Median adherence to Seniors Exercise Park independent training sessions was 28.2% (IQR = 8.4 - 45.6) (baseline to 18 weeks) and 26.3% (IQR = 4.9 - 41.7) (weeks 19 to 24) (see Table 6.4).

6.4.3 Practicality (including safety)

One physiotherapist delivered the supervised exercise sessions. Each session consisted of three to eight participants, and they exercised in the same group throughout the intervention. Seven groups of participants were staggered for training across 12 months. All participants could perform the prescribed exercises at the Seniors Exercise Park with supervision, and subsequently, unsupervised. Seven (15%) participants reported some discomfort (e.g., muscle or joint soreness) or pain due to aggravating a pre-existing condition (e.g., osteoarthritis, rheumatoid arthritis, scoliosis) or injury (e.g., previous injury to the foot, shoulder, or hip). Exercises (i.e., intensity, movement patterns) were adjusted when any discomfort or pain was reported. One participants' hand caught a wood splinter while exercising on the gangway of the Seniors Exercise Park equipment. The splinter was removed, and first aid was administered by the physiotherapist. No falls, or other adverse events occurred during the intervention and/or unsupervised independent practice at the Seniors Exercise Park.

Table 6.4. Number of sessions attended and median adherence (%) to supervised and unsupervised independent Seniors Exercise Park practice

Baseline to 18 weeks								Week 19 to 24	
Supervised training (22 sessions)						Independent practice (14 sessions)		Independent practice (12 sessions)	
Participants recruited (n=46)		Participants who completed the intervention (n=36)		Dropouts (n=10)		Participants who completed the intervention (n=36)		Participants at follow-up (n=32)	
Mdn number of sessions (IQR)	*Mdn* adherence % (IQR)	*Mdn* number of sessions (IQR)	*Mdn* adherence % (IQR)	*Mdn* number of sessions (IQR)	*Mdn* adherence % (IQR)	*Mdn* number of sessions (IQR)	*Mdn* adherence % (IQR)	*Mdn* number of sessions (IQR)	*Mdn* adherence % (IQR)
20.0 (17.5-21.0)	90.9 (79.5-95.5)	20.0 (19.0-21.0)	90.9 (86.4-95.5)	6.0 (1.0-15.8)	27.3 (4.5-71.6)	3.4 (1.1-5.1)	28.2 (8.4-45.6)	2.8 (0.5-4.2)	26.3 (4.9-41.7)

Note. *Mdn* = median; IQR = interquartile range; mins = minutes; % = percentage.

6.4.4 Efficacy testing

6.4.4.1 Baseline to 18 weeks

Statistically significant improvements in balance and mobility (CBMS-Home and Four Square Step Test), lower body strength and fast walking speed (large effect size, p <.001) and physical activity levels (moderate effect size, $p = .002$) were demonstrated following the intervention (see Table 6.5). Statistically significant improvements in psychosocial and quality of life outcomes (moderate or large effect sizes, $p \leq .001$) and loneliness (small effect size, $p = .004$) were also demonstrated.

6.4.4.2 Baseline to 24 weeks

Statistically significant improvements in all physical performance outcomes (large effect size, $p < .001$), physical activity levels, psychosocial outcomes and quality of life (moderate or large effect sizes, $p \leq .001$) were also found from baseline to 24 weeks.

6.4.4.3 18 to 24 weeks

Statistically significant improvements were observed in balance and mobility (CBMS-Home and Four-Square Step Test), and fast walking speed (moderate effect size, $p < 0.001$). No significant changes were observed for the remaining physical performance and psychosocial outcomes. No significant changes were observed for the remaining physical performance outcomes, potentially due to inadequate frequency and intensity of exercises (e.g., lower body strength) when the participants exercised on their own. The changes in the psychosocial and quality of life outcomes were not significant possibly because some of the participants may not have met as a group to exercise, and the lack of social connectedness could have influenced their emotional well-being.

Table 6.5. Outcomes, predicted marginal means, estimated mean differences, 95% confidence intervals and effect size

	Baseline	18 weeks	24 weeks	Baseline to 18 weeks			Baseline to 24 weeks			18 to 24 weeks		
Outcomes measures	**Predicted marginal mean (95% CI)**	**Predicted marginal mean (95% CI)**	**Predicted marginal mean (95% CI)**	**Estimated mean differences (95% CI)**	***P* value**	**Effect size [Cohen's *d*] (95% CI)**	**Estimated mean differences (95% CI)**	***P* value**	**Effect size [Cohen's *d*] (95% CI)**	**Estimated mean differences (95% CI)**	***P* value**	**Effect size [Cohen's *d*] (95% CI)**
Physical Performance												
CBMS-Home	30.7 (28.1 – 33.3)	49.8 (47.1 – 52.6)	54.4 (51.5 – 57.2)	19.1 (17.0 – 21.3)	< .001	2.2[c] (1.6 – 2.7)	23.7 (21.4 – 25.9)	< .001	2.7[c] (2.1 – 3.3)	4.6 (2.3 – 6.8)	< .001	-0.5[b] (0.1 – 1.0)
Four Square Step Test (s)	10.0 (9.5 - 10.6)	8.7 (8.3 – 9.1)	8.1 (7.8 – 8.5)	-1.3 (-1.5 – -1.2)	< .001	-0.9[c] (-1.3 – -0.4)	-1.9 (-2.2 – -1.7)	< .001	-1.3[c] (-0.3 – -1.5)	-0.5 (-0.6 – -0.5)	< .001	-0.5[b] (-1.0 – 0.0)
Fast walking speed (m/s)	1.4 (1.3 – 1.4)	1.6 (1.5 – 1.6)	1.7 (1.6 – 1.8)	0.2 (0.2 – 0.2)	< .001	0.8[c] (0.3 – 1.2)	0.3 (0.3 – 0.3)	< .001	1.4[c] (0.9 – 1.9)	0.1 (0.1 – 0.1)	< .001	0.6[b] (0.1 – 1.1)
Five Times Sit to Stand Test (s)	12.5 (11.6 – 13.6)	9.3 (8.6 – 10.0)	8.8 (8.2 – 9.5)	-3.3 (-3.6 – -3.0)	< .001	-1.1[c] (-1.6 – -0.6)	-3.8 (-4.1 – -3.4)	< .001	-1.3[c] (-1.8 – -0.8)	-0.5 (-0.5 – -0.5)	.139	-0.2[a] (-0.7 – 0.2)
Physical Activity Scale for the Elderly	88.4 (75.9 – 101.0)	110.9 (97.0 – 124.7)	117.1 (102.7 – 131.6)	22.4 (21.1 – 23.7)	.002	0.5[b] (0.1 – 1.0)	28.7 (26.8 – 30.6)	< .001	0.7[b] (0.2 – 1.1)	6.3 (5.6 – 6.9)	.423	0.1 (-0.3 – 0.6)
Psychosocial Outcomes and Quality of Life												
EQ-5D-5L	0.8 (0.8 – 0.9)	0.9 (0.9 – 1.0)	0.9 (0.9 – 1.0)	0.1 (0.1 – 0.1)	< .001	0.7[b] (0.3 – 1.2)	0.1 (0.1 – 0.1)	< .001	0.8[c] (0.3 – 1.2)	0.0 (0.0 – 0.0)	.923	0.0 (-0.5 – 0.5)
EQ-5D-5L Visual Analogue Scale	77.0 (73.6 – 80.5)	88.7 (84.4 – 93.1)	84.6 (80.3 – 88.9)	11.7 (10.7 – 12.6)	< .001	0.9[c] (0.5 – 1.4)	7.5 (6.6 – 8.5)	.001	0.6[b] (0.2 – 1.1)	-4.1 (-4.2 – -4.1)	.087	-0.3[a] (-0.8 – 0.2)
Modified Falls Efficacy Scale	9.2 (9.1 – 9.4)	9.8 (9.7 – 10.0)	9.9 (9.8 – 10.1)	0.6 (0.6 – 0.6)	< .001	1.3[c] (0.8 – 1.8)	0.7 (0.7 – 0.7)	< .001	1.5[c] (1.0 – 2.0)	0.1 (0.1 – 0.1)	.297	0.2[a] (-0.3 – 0.7)
Self-Efficacy for Exercise	61.0 (55.8 – 65.4)	74.4 (70.6 – 77.8)	73.0 (68.9 – 76.8)	13.4 (12.4 – 14.8)	< .001	0.9[c] (0.5 – 1.4)	12.0 (11.3 – 13.0)	< .001	0.8[c] (0.3 – 1.3)	-1.4 (-1.7 – -1.1)	.567	-0.1 (-0.6 – 0.4)
3-Item Loneliness Scale	4.4 (4.0 – 4.7)	3.9 (3.5 – 4.2)	3.6 (3.3 – 4.0)	-0.5 (-0.5 – -0.5)	.004	-0.4[a] (-0.9 – 0.0)	-0.7 (-0.8 – -0.7)	< .001	-0.7[b] (-1.1 – -0.2)	-0.2 (-0.3 – -0.2)	.134	-0.2[a] (-0.7– 0.2)
WHO-5 Well-Being	68.5 (64.3 – 72.5)	75.3 (71.2 – 79.3)	75.2 (70.9 – 79.2)	6.8 (6.8 – 6.9)	< .001	0.5[b] (0.1 – 1.0)	6.7 (6.6 – 6.7)	.001	0.5[b] (0.0 – 1.0)	-0.2 (-0.3 – 0.0)	.925	0.0 (-0.5 – 0.5)

Note. CBMS-Home = Community Balance and Mobility Scale-Home; n = number of participants; CI = confidence interval; s = seconds; m/s = meter per seconds; [a]Small effect size; [b]Medium effect size; [c]Large effect size.

6.4.5 Adaptation

Modifications (e.g., cuffed weights instead of elastic bands for hip exercises) were made to the Sales et al. (2015) protocol in this study. These adjustments were accepted well by the participants.

Some participants (n = 13) combined the Seniors Exercise Park exercises (e.g., tandem walk while using snake pipe) with other similar exercises in different environments (i.e., pool and/or home) and a few (n = 6) incorporated these exercises (e.g., tandem walk) in the pool and/or home without visiting the Seniors Exercise Park during weeks 19 to 24. These additional exercises were recorded in the participant's exercise diaries, but not included in the calculation of adherence to independent training.

6.4.6 Acceptability

The qualitative outcomes associated with this intervention revealed that participants were satisfied with the program and perceived positive health benefits after participating in the program (Ng et al, paper under review).

6.5 Discussion

The results suggest that using a gradual, reduced supervised approach during Seniors Exercise Park training over 18 weeks is feasible across most of the domains recommended by Bowen et al. (2009). Demand was adequate with high interest from residents in a retirement village, although there were dropouts during the 24 week intervention. High adherence was reported during supervised training, however adherence to independent training was relatively low. The program was deemed safe, with no falls or adverse events occurring. All health outcomes demonstrated significant improvements (small to large effect sizes) at both 18 and 24 weeks. The positive health outcomes suggest the potential to promote supervised Seniors Exercise Park programs among older adults with mild balance dysfunction. Together, these findings show a supervised Seniors Exercise Park intervention is feasible for older adults with mild balance dysfunction. However, future programs need to develop better strategies to manage dropouts and adherence to independent training.

This study reported a high adherence (90.9%) to supervised training, which was higher than previous Seniors Exercise Park studies (i.e., previously reported adherence rates were 79.6% and 86%) (Levinger et al., 2020; Sales et al., 2017), suggesting that participants valued the interaction and guidance from the physiotherapist, and the supported group dynamics in the formal supervised sessions. However, the high adherence during supervised training was not transferred to independent practice, with the median adherence of 28.2% once the supervision was reduced, and 26.3% at six weeks follow-up. Higher adherence rates were reported by Levinger et al. (2020) during their six months follow-up because participants could choose to attend supervised or unsupervised independent training (Levinger et al., 2020). Reasons affecting adherence during unsupervised, independent practice in this study included lack of time due to other obligations (e.g., family and/or medical appointments), poor health, pain due to pre-existing conditions and extreme weather (i.e., weather too hot or raining) (Ng et al., paper under review). Understanding participants' characteristics (e.g., health status, previous lifestyle habits and goals), motivators and barriers before starting the program (Collado-Mateo et al., 2021), training peers (i.e., participants within the program) as leaders (Khong et al., 2017; Thøgersen-Ntoumani et al., 2019) to lead the independent practice training and installing a shade to cover the Seniors Exercise Park (Levinger, Dunn, et al., 2021; Levinger et al., 2018) may enhance adherence during independent practice and should be considered in the future. In addition, future research should develop strategies to enhance adherence to independent training among older adults with mild balance dysfunction.

The dropout rate for this study was 21.7% (at 18 weeks) which was higher compared to previous Senior Exercise Park studies (i.e., 13% to 15.8%) (Levinger et al., 2020; Sales et al., 2017). In contrast to previous studies (Levinger et al., 2020; Sales et al., 2017), a higher number of participants (n = 8 (17.4%)) dropped out due to health issues (medical problems, pain, physical injury) and a few participants (n = 2 (4.3%) dropped out due to lack of time. To assist participants in continuing to use a Senior Exercise Park when health issues arise, the person delivering the program may consider collaborating with the participants' health professional/s to support them until they recover to their previous levels of health or physical condition. Participants can then hopefully re-join the program and continue to improve their physical fitness. A small percentage (i.e., 14.3%) of sessions were cancelled and replaced due to extremes of weather. Although, this was a slightly higher percentage of sessions compared to previous Seniors Exercise Park studies (Levinger et al., 2020; Sales et al., 2017), all classes were replaced within the 18 week intervention.

No falls or serious adverse events were reported, which aligns with previous Senior Exercise Park studies (Levinger et al., 2020; Sales et al., 2017). This suggests that the Seniors Exercise Parks, after a period of supervision, are safe as a physical activity option for older adults with mild balance dysfunction to maintain their physical health independently and to improve their balance, strength and mobility. One minor incident occurred (i.e., participants' hand caught a small wood splinter) highlighting the need for maintenance by the owners of the Seniors Exercise Park equipment.

The participants' walking speed, lower body strength, balance and mobility improved at 18 and 24 weeks. In addition, participants' walking speed, balance and mobility continued to improve between 19 to 24 weeks. Improvements in physical activity levels also occurred at 18 and 24 weeks and were maintained from 19 to 24 weeks. The study findings are consistent with the results of a previous study (Levinger et al., 2020) confirming that the Seniors Exercise Park programs can potentially increase physical performance and physical activity levels in older adults. A plausible explanation for the improvements in physical performance is the specificity of the Seniors Exercise Park equipment (e.g., walking on the gangway to address balance, stairs to address strength and function), which likely addressed impairments of the participants (e.g., poor balance, decreased lower body strength). These results also suggest that the participants were most likely doing other activities, as well as the smaller number of Seniors Exercise Park unsupervised sessions to maintain their physical performance during weeks 19-24. This finding is notable as our study recruited participants who were considered inadequately active before starting the study and suggests the potential of this outdoor exercise intervention to reduce inactivity.

All psychosocial outcomes and quality of life also showed significant improvements from baseline to 18 weeks and 24 weeks. In contrast to a previous Seniors Exercise Park study (Levinger et al., 2020), the present study reported a significant improvement in self-efficacy for exercise from baseline to 18 and 24 weeks, with this level maintained from 19 to 24 weeks. This suggests that as participants adhered to the exercise over time, their perceived efficacy for exercising improved. Factors that may have reinforced the participants' exercise efficacy include social support within the group and positive experiences during the intervention program (McAuley et al., 2003).

6.6 Strengths and limitations

This study had several strengths and limitations. This research is the first to provide evidence that it is feasible and safe for older adults with mild balance dysfunction to exercise both with supervision and independently using the Seniors Exercise Park. The efficacy testing component of the feasibility study also highlighted for the first time that this type of intervention can improve physical performance, psychological outcomes, and quality of life in older people with mild balance dysfunction. The participants were recruited from a single setting and the small number of male participants recruited limited the generalisation and diversity of the sample. Therefore, future studies need to include strategies to recruit participants from the wider community and to target older males also with mild balance dysfunction. Although some aspects of the demand for the Seniors Exercise Park program have been reported in this study, future research should also explore the broader level of interest in regular use of this type of park equipment among communities surrounding these park locations.

The standardised questionnaires (i.e., WHO-5 Well-Being Index, UCLA Three Item Loneliness Scale, and EQ-5D-5L) may be prone to bias because the participants' responses may not reflect their actual psychosocial and quality of life status. However, these questionnaires have been used in research to evaluate psychosocial and quality of life outcomes in older adults (Dorhout et al., 2021; Ejiri et al., 2021; Kotwal et al., 2021). COVID-19 lockdowns and mandatory mask wearing occurred at certain times during the intervention. This may have affected independent practice among the participants during the study and may have influenced the psychosocial data due to the increased socialisation after lockdowns. This study used a single group pre-post study design that did not have a control group and the length of follow-up for independent training was short (i.e., six weeks). Future studies should include a control group and to assess adherence to independent practice over a more sustained period. Time and the distance participants need to travel to the Seniors Exercise Park could have influenced the participation rate of the participants. Therefore, future studies may want to evaluate how these factors influence Seniors Exercise Park programs in older adults with mild balance dysfunction. Researcher bias may have occurred because the same researcher conducted the assessments and delivered the intervention. To minimise researcher bias, maximum likelihood estimation modelling methods were utilised to incorporate and analyse all available data points.

6.7 Conclusion

The findings suggest that a supervised Seniors Exercise Park training program transitioning to independent training is feasible and safe in older adults with mild balance dysfunction. This training program can improve the physical (e.g., balance, lower body strength) and psychosocial health (e.g., mental well-being) of older adults with mild balance dysfunction. Strategies are needed to manage dropouts and adherence to independent training in future programs. Private and not for profit organisations and governments may consider investing in Seniors Exercise Park equipment to offer a novel form of physical activity for older adults with mild balance dysfunction.

Chapter 7 : Experiences of older adults with mild balance dysfunction who participated in a supervised Seniors Exercise Park program progressing to independent practice

Chapter outline

The qualitative study presented in this chapter builds on the quantitative feasibility findings on the Seniors Exercise Park program described in Chapter 6. This study explores the experiences of older adults who participated in the Seniors Exercise Park program and describes the factors influencing their participation during the supervised 18 week and unsupervised independent practice from week 19 to 24.

The study described in this chapter is presented in manuscript format. The study manuscript ‘Ng, Y.L., Hill, K.D., & Burton, E. Experiences of older adults with mild balance dysfunction who participated in a supervised Seniors Exercise Park program progressing to independent practice’ is currently under second review.

7.1 Abstract

Older adults with mild balance dysfunction can benefit from early intervention. This research explored the experiences of older adults with mild balance dysfunction participating in an 18 week supervised outdoors Seniors Exercise Park program and six weeks of unsupervised, independent practice. Factors influencing attendance and independent practice were also explored. Semi-structured face-to-face interviews were conducted with 24 participants (mean age = 77.4 years, *SD* = 5.4) and 22 participants (mean age = 77.5 years, *SD* = 5.6) after 18 and 24 weeks respectively. The data were analyzed using reflexive thematic analysis. Many participants perceived improvements in health and responded positively to the supervised Seniors Exercise Park program. Factors supporting attendance included building social connections and positive instructor personality. Barriers to training included competing time demands and poor health. These insights suggest that a group-based Seniors Exercise Park supervised program was well-accepted and can be an option to improve the health of older adults with mild balance dysfunction.

7.2 Introduction

Engaging in regular physical activity is important to maintain physical function (Piercy et al., 2018), prevent falls (Sherrington, Fairhall, Kwok, et al., 2020), and improve the quality of life of older adults (Langhammer et al., 2018), but many older adults are insufficiently active (Bauman et al., 2016). Up to three-quarters of older adults in Australia do not meet the recommended 30 minutes of moderate intensity physical activity daily recommended by the Australian National Guidelines (Australian Institute of Health and Welfare, 2020). Older adults often start new physical activity programs; however, many then stop their involvement after a period of time (Garmendia et al., 2013), and the fitness gains made are often lost (Esain et al., 2019; Martínez-Aldao et al., 2020). Reasons for discontinuing program participation included poor health, lack of motivation, lack of peer bonding, and lack of time (Biedenweg et al., 2014). Therefore, there is a need to explore how to encourage older adults to participate and continue in regular physical activity and to use novel activity options or equipment to sustain ongoing physical activity.

Outdoor exercise equipment installed in parks or private facilities may provide additional opportunities for older adults to engage in regular physical activity in a manner different to what they usually experience. Improvements in some physical performance outcomes (Chow et al., 2021; Kim et al., 2018; Kowalska & Czesak, 2021; Leiros-Rodríguez & García-Soidan, 2014) and quality of life (Leiros-Rodríguez & García-Soidan, 2014) have been reported in older adults after participating in supervised outdoor exercise equipment interventions. Some outdoor exercise equipment is built specifically for older adults (known as Seniors Exercise Parks) (Levinger et al., 2020). They are designed to target physiological domains associated with aging (e.g., balance, strength) (Levinger et al., 2018). Seniors Exercise Parks are unique because they include balance training equipment, whereas other outdoor exercise equipment predominantly does not. Previous studies have shown that a continuous supervised program at a Seniors Exercise Park improved physical performance (Levinger et al., 2020; Sales et al., 2017) and was perceived favorably by older adults living independently in the community (Sales et al., 2018). A range of factors were reported influencing Seniors Exercise Park program participation. Supervision, health benefits and socialization encouraged program participation (Levinger, Dunn, et al., 2021). Health problems, other obligations, and weather were deterring factors to participation (Levinger, Dunn, et al., 2021). Previous systematic reviews reported similar factors influencing physical activity participation (Franco et al., 2015; Spiteri et al., 2019; Yarmohammadi et al., 2019).

A population that may benefit from a physical activity program using Seniors Exercise Parks are older adults with mild balance dysfunction. For the purpose of this paper, mild balance dysfunction refers to older people who remain community ambulant, do not require any more support than a single point stick for outdoors mobility, have had no more than one fall in the preceding 12 months, but whose performance on either one or both of two simple clinical tests (the Step Test or Functional Reach) fall below defined cut-off scores for their age (see Methods) (Williams et al., 2015). Older adults with mild balance dysfunction may not consult health professionals (Williams et al., 2015) for a number of reasons, including lack of understanding about improving their balance, perceiving their reduced balance performance is part of normal aging, or not knowing what programs are available for them to improve their balance. Without intervention, older adults with mild balance dysfunction are likely to decline to moderate or severe levels of balance impairment (Yang et al., 2012).

Older adults with mild balance dysfunction have been shown to improve balance performance and lower extremity strength after undergoing prescribed physical activity programs at home (Williams et al., 2015; Yang et al., 2012). A previous qualitative study on older adults with mild balance dysfunction participating in a home exercise program, which consisted of balance, resistance, and walking training identified lack of time and types of exercise as barriers (Meyer et al., 2016). Although some evidence from research demonstrated positive effects (Williams et al., 2015; Yang et al., 2012) and factors influencing home exercise programs in older adults with mild balance dysfunction (Meyer et al., 2016), the use of outdoor exercise equipment in this group of older adults has not been investigated. A combination of determinants can influence physical activity behavior (Eynon et al., 2019; Lachman et al., 2018; van Stralen et al., 2009). These determinants include individual (e.g., baseline physical activity, motivation, perceived benefits, enjoyment, self-efficacy), environment (e.g., access to exercise facilities), and social determinants (e.g., social network) (Eynon et al., 2019; Lachman et al., 2018; van Stralen et al., 2009). It is unknown whether older adults with mild balance dysfunction would enjoy and potentially benefit from participating in a group-based Seniors Exercise Park program. Therefore, the aim of this qualitative study was to explore (i) older adults' experiences and perceptions of participating in an 18 week supervised Seniors Exercise Park program and a subsequent six weeks of independent self-practice using the Seniors Exercise Park and (ii) the factors influencing regular participation during a supervised Seniors Exercise Park program and six weeks of independent practice.

7.3 Methods

7.3.1 Study design

This qualitative study was part of a feasibility, pre- and post-intervention study design (i.e., outcomes assessed at baseline, 18 weeks, and 24 weeks, paper currently under review). Two face-to-face interviews were undertaken, the first after the 18 week intervention and the second after six weeks of unsupervised training. For this qualitative study, an interpretive phenomenological approach was used to understand the lived experience (Carpenter, 2013; Neubauer et al., 2019) of older adults with mild balance dysfunction after participation in the Seniors Exercise Park intervention program. The interpretive phenomenological approach was selected because this approach enabled us to fully explore the lived experience of the participants within their current environment (Lopez & Willis, 2004; Neubauer et al., 2019).

7.3.2 Ethics approval

Curtin University Human Research Ethics Committee approved the research (Approval Number: HRE2019-0734).

7.3.3 Participants and study setting

Participants were recruited between June 2020 to April 2021 from a retirement village in Perth, Australia. This retirement village had an existing Seniors Exercise Park installed within their village. Retirement villages are housing developments constructed to support older adults who are relatively independent with access to shared facilities (e.g., gym) and social activities (Gardner et al., 2005). Study inclusion criteria were: adults aged 65 years or above, walking independently using no more than a walking stick (Williams et al., 2015), experienced no more than one fall in the past 12 months (Williams et al., 2015), reduced physical activity level (i.e., not meeting

Australian Physical Activity guidelines of 30 minutes of moderate intensity physical activity most days/daily), and/or expressed concerns about balance, were deemed as suitable to participate in exercise using either (1) the Physical Activity Readiness Questionnaire for Everyone (PAR-Q)+ (Warburton, Bredin, et al., 2011), or (2) had received clearance from a General Practitioner to participate; and had no cognitive impairment (Abbreviated Mental Test Score >7/10) (Jackson et al., 2013). An additional inclusion criterion was that older adults needed to meet previously defined criteria for having mild balance dysfunction, with performance on one or both of two commonly used clinical tests of dynamic standing balance (the Step Test (Hill, Bernhardt, et al., 1996) and Functional Reach (Duncan et al., 1990)) being below defined cut-off scores for their age (i.e., for those 65-75 years of age, <17 steps / 15 seconds and/or <29 cm respectively; and for those aged 75 years and older, <15 steps / 15 seconds and/or <27 cm respectively) (Williams et al., 2015).

7.3.4 Supervised intervention program (Week 1-18)

The Seniors Exercise Park was built by Lappset, Lark Industries Pty Ltd, and was located at a retirement village in Perth, Western Australia (see Figure 7.1). The Seniors Exercise Park includes many different types of exercise~~s~~ equipment designed to challenge balance, strength, function, range of motion, and dexterity (see Levinger et al. (2019) "Additional File 1" at this website for a copy of the exercises: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-7125-2#MOESM1). A sign showing how to use each piece of exercise equipment including simple instructions was available at the Seniors Exercise Park for the residents to assist them with self-directed exercise practice. Each of these exercises take place in different equipment workstations. For example, several stations were designed to challenge and improve balance performance – such as the balance beam (which involved walking along a beam) and gangway (which involved walking along a bridge).

Figure 7.1. Seniors Exercise Park

Note. Photograph courtesy of Ng (2021).

The Seniors Exercise Park exercises prescribed were adapted and modified from a previously published protocol (Sales et al., 2015). Modifications to the published protocol (Sales et al., 2015) included using cuffed ankle weights instead of elastic bands for hip exercises, and participants alternated between two sets of exercise stations instead of an incremental number of exercise stations at certain weeks during the intervention (see Appendix 13) and a standard chair was used for sit to stand exercises instead of a bench at the Seniors Exercise Park.

Participants were asked to attend twice weekly sessions at the Seniors Exercise Park for 18 weeks. Supervision by the same physical therapist (NYL) was provided at the sessions twice weekly initially, and supervised sessions reduced in frequency as the weeks progressed (see Table 7.1).

Table 7.1. Supervised training sessions throughout 18 weeks and 6 weeks independent practice

Weeks of supervised component of the program																																			
1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
●	●	●	●	●	●	●	●	●	●	●	●	●		●		●		●		●			●			●				●				●	●

Weeks of independent practice part of program											
1		2		3		4		5		6	

● Supervised training sessions ☐ Independent practice

Adapted from Ng, Y.L., Hill, K.D., Levinger, P., Jacques, A., & Burton, E. (2022). Seniors Exercise Park program for older adults with mild balance dysfunction – A feasibility study. *Disability and Rehabilitation*, Advance online publication, 1 – 12. https://doi.org/10.1080/09638288.2022.2112984

A total of 22 supervised sessions were provided across 18 weeks. Each session consisted of five minutes warm up and cool down respectively and up to 50 minutes of exercises using the equipment (total session duration: 60 minutes). Participants moved to the next station once they had completed the number of repetitions prescribed, which was individualized to the ability of the participants. The exercises were individualized by the supervising physical therapist, based on an initial assessment of the participant, and observation of their performance at various exercise stations. Individualization of exercises included reducing or increasing the number of repetitions, reducing or increasing the difficulty of the exercises (e.g., changing base of support) and modifying the exercises to accommodate participants' health conditions or ability (e.g., pain or limited range of motion or reduced exercise tolerance). Rest breaks were provided between stations if required. Each group session consisted of three to eight participants and the participants remained in the same group throughout 18 weeks. Seven groups of participants were recruited and entered the program at different times during the year. During the last three supervised sessions of the 18 week program, participants were briefed and given handouts about exercise and safety instructions (e.g., do not use the equipment after heavy rain) to use during their independent practice at the exercise park over the subsequent six weeks.

7.3.5 Independent Seniors Exercise Park practice (Week 19-24)

After completing the supervised program (weeks 1-18), participants were encouraged to continue Seniors Exercise Park practice independently for another six weeks, during which the physical therapist was not in attendance. Participants were informed to continue two hours of Seniors Exercise Park practice weekly on their own (weeks 19-24). However, participants were informed that they could contact the physical therapist if they needed assistance, and the consultations were recorded. Participants recorded their visits to the Seniors Exercise Park in a diary, which was collected after completion of the entire program (after week 24).

7.3.6 Data collection

Participants were recruited through word of mouth, contacting participants who consented to be contacted from a research database and publicity across the retirement village. All participants were provided with details of the study. Written consent was obtained before study commencement (including data collection). Participants completed the standardized questionnaires individually and the physical performance tests were conducted one-to-one with the physical therapist at the retirement village. Participants who completed the intervention were interviewed face-to-face individually by the physical therapist (NYL) who delivered the intervention. These interviews occurred on the day of their follow-up assessments (i.e., after weeks 18 and 24). All interviews were audio-recorded. An interview guide was used (see Appendix 9), and additional questions were asked where required to tease out further information. The same physical therapist, NYL wrote notes during the interview. An experienced qualitative researcher (EB), supervised NYL throughout the data collection process. Interviews were conducted to the point of saturation when no further information and interpretation were gained (Braun & Clarke, 2021). The researchers had no occupation or role at the retirement village, where the Seniors Exercise Park was located.

7.3.7 Data analysis

The interviews were transcribed verbatim by an independent transcriptionist and were checked for accuracy by the physical therapist. Reflexive thematic analysis is a qualitative data analysis approach that enables the researcher to identify and analyze patterns or themes in the data (Braun & Clarke, 2019; Byrne, 2022). The data were analyzed using an inductive approach, whereby the codes were derived from the data and did not have a preconceived framework or theory (Braun et al., 2021; Byrne, 2022; Clarke et al., 2015). NYL and EB analyzed the data separately. All data were transferred and analyzed in Microsoft Excel so that the patterns could be easily identified (Bazeley, 2021; Ose, 2016), this has been used in previous qualitative studies (Finlay et al., 2021; Nyman et al., 2013; Portz et al., 2019; Vick et al., 2018). The relevant phrases were highlighted in each interview and were assigned a code. Codes with similar meanings were collated into groups. Similar topics were grouped to form themes and sub-themes. Steps were taken to improve the trustworthiness of the data (Morse et al., 2002; Shenton, 2004). These included meeting data saturation (Morse et al., 2002), NYL conducting the interviews and analyzing the data simultaneously (Morse et al., 2002), another researcher (EB) initially analyzing the data independently before coming together with NYL to compare, combine and refine results, NYL and EB checking the data (including the notes) repeatedly to reconfirm the themes that emerged from the data, and sending the results to KH for final review. In addition, discussions were also held to refine ideas and confirm the results of the thematic map.

7.4 Results

7.4.1 Participant demographics

Thirty-six participants completed the 18 week intervention, and 32 participants were followed-up after 24 weeks. Twenty-four participants and 22 participants who took part in the Seniors Exercise Park intervention study were interviewed after 18 and 24 weeks respectively. One participant declined to be interviewed after 24 weeks and another did not complete the 24 week assessment or interview due to medical reasons. The duration of all the interviews ranged from seven to 37 minutes. The characteristics of the participants are shown in Table 7.2. Average balance performance for participants was reduced at time of commencement of the exercise program, especially on the Step Test (mean = 10.8 steps / 15 seconds) (Table 7.2) when compared to normative scores (Hill, Bernhardt, et al., 1996).

Fully supervised intervention included six themes and 21 sub-themes and independent practice included four themes and 17 subthemes.

Table 7.2. Baseline characteristic of participants

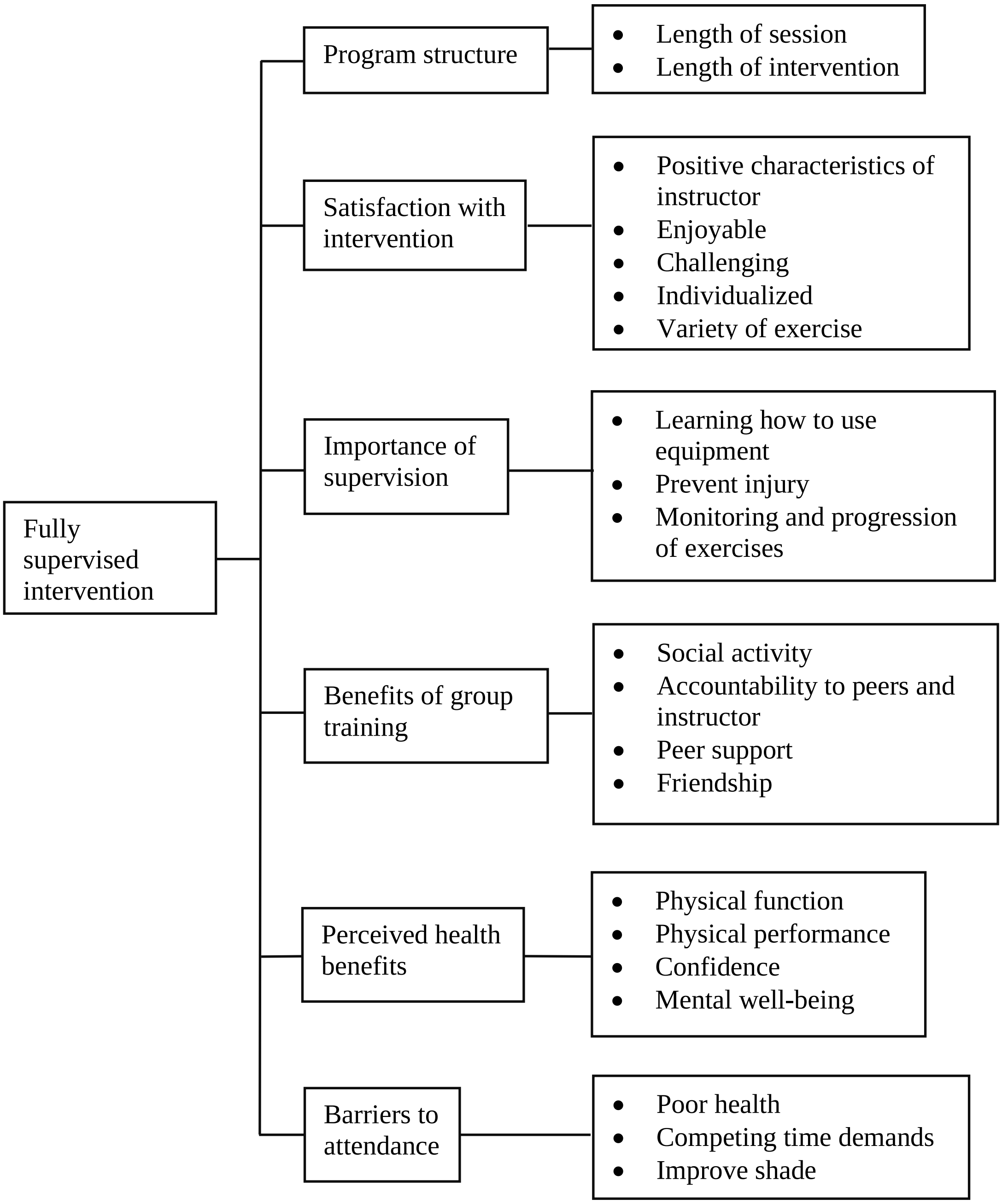
Variable	**Participants (n = 24)**
Age [*M* (years) (*SD*)]	77.4 (5.4)
Sex [male n (%) : female n (%)]	3 (12.5) : 21 (87.5)
Highest education level achieved [n (%)]	
High school	4 (16.7)
University	9 (37.5)
Other	11 (45.8)
Medical conditions [n (%)]	
Hypertension	16 (66.7)
Musculoskeletal conditions (e.g., scoliosis, chronic backache, bursitis, spondylitis)	8 (33.3)
Hyperlipidemia	7 (29.2)
Renal, bladder and gastrointestinal conditions	6 (25.0)
Respiratory conditions	6 (25.0)
Cardiovascular conditions	5 (20.8)
Osteoporosis/Osteopenia	5 (20.8)
Osteoarthritis	5 (20.8)
Diabetes	3 (12.5)
Sleep apnea	3 (12.5)
Gout	2 (8.3)
Macular degeneration	1 (4.2)
Depression	1 (4.2)
Other conditions (e.g., CREST syndrome, eczema, lichen planus, hypothyroid, Bowen's disease)	6 (25.0)
Used a walking stick [n (%)]	3 (12.5)
Joint replacement [n (%)]	7 (29.2)
Step test [*M* (steps in 15 seconds) (*SD*)]	10.8 (2.3)
Functional reach [*M* (cm) (*SD*)]	32.1 (2.7)
Modified Falls Efficacy Scale [*Mdn* (IQR)]	9.4 (8.9-9.9)
Attendance during supervised training [*Mdn* (%) (IQR)]	90.9 (87.5-95.5)

Note. *M* = mean; *SD* = standard deviation; n = number of participants; % = percentage; cm = centimeter; *Mdn* = median; IQR= interquartile range; CREST = calcinosis; Raynaud's phenomenon, esophageal dysmotility, sclerodactyly and telangiectasia.

7.4.2 Fully supervised intervention

The six themes resulting from the fully supervised intervention were program structure; satisfaction with the intervention; importance of supervision; benefits of group training; perceived health benefits; and barriers to attendance. Figure 7.2 presents the thematic map for the fully supervised theme.

Figure 7.2. Fully supervised intervention thematic map



7.4.2.1 Program structure

Many participants commented that the 18 week duration was adequate to learn how to use the Seniors Exercise Park equipment and to assist in forming a habit. Three participants stated they would have preferred a shorter intervention length because the exercises became repetitive, or they could do them easily. All participants were satisfied with the length of each session (i.e., 60 minutes).

> "*I think it is good umm, because it… you know, like when we are doing it twice a week, we are getting to learn how to do those exercises and you are teaching us the exercises so that we can do them independently. And, you know, and we can do that. And you know, when you are gradually weaning us off being supervised and we can… once this program is finished, we can just come down and just go straight into those exercises because we know what we are doing*." (ID8)

7.4.2.2 Satisfaction with the intervention

All participants were satisfied with the intervention because of the instructors' positive personality, the intervention was enjoyable and challenging, the exercises had a lot of variety on a single piece of equipment, and the exercises were individualized. The participants used words such as "*supported*" (ID18), "*encouraging*" (ID22), "*patient*" (ID15), "*caring*" (ID1), "*passionate*" (ID24) and "*kind*" (ID4) to describe the instructor. Many found the intervention to be fun because they enjoyed the exercises and the company of their peers and instructor. Although they enjoyed the intervention, they also found it challenging, with many describing an improvement over time even though they felt the exercises were difficult in the beginning, for example

> "*I was shocked at the improvement, …..when I first started, how difficult the exercises were, which I had poo hooed* [sic] *myself and I thought that*

was nothing. Well, not so. Not so at all. It was challenging and, you know, I learnt a lot." (ID9)

Having a lot of variety, where different movements could be undertaken on a single piece of equipment (e.g., tandem walk to tiptoe walk using the snake pipe), was also viewed positively by the participants. Although the same equipment was used by all of the participants, it was able to be individualized and the instructor targeted the areas that each individual participant needed to improve. For example,

"*The fact that err… we were picked up for… you could see that… like stepping backwards etc. was an issue for me for example, or I could see for other people, you were picking up on what they needed extra attention on. I thought that was really good*." (ID21)

7.4.2.3 Importance of supervision

Participants described a number of reasons why they valued being supervised when initially participating in the Seniors Exercise Park program. They liked having a clear explanation and demonstration of how to use the equipment correctly, they enjoyed having their performance and progress monitored and increased over time and perceived having supervision prevented them from sustaining an injury.

"*With the wave* [dynamic balance and shoulder range of motion exercise] *you know, you had to be shown how to use that so that you wouldn't fall, umm… yeah, I think we definitely needed…it needed the supervision otherwise we wouldn't use the equipment properly and then it wouldn't do what it's designed to do*." (ID16)

7.4.2.4 Benefits of group training

All participants liked training in a group because they viewed this as a social activity and an opportunity to interact with their peers. They also described their role within the group was to encourage each other but be accountable to both their peers and the instructor by making the commitment to participate in every session.

> "*Well, you encourage one another by being there. Each week most people turned up and if they didn't, they gave a good reason the week before. So, everybody was committing themselves and that bonds a group as well.*" (ID9)

By the end of the 18 week intervention they valued the friendships that had developed, and when someone could not remember their exercises, peer support was available, and they were not only reliant on the instructor, which was described positively, "*If one can't remember it, somebody else can, and so you know, we help each other that way*" (ID8).

7.4.2.5 Perceived health benefits

All participants, except two, communicated that they felt the training improved one or more of the following: physical function (e.g., standing up from a chair), physical performance (e.g., balance, muscle strength, fitness, and posture), confidence, and/or mental well-being. Half of the participants perceived improvements in balance, which was important, particularly with this group of older adults with mild balance dysfunction.

> "*Yes, I used to have to sit down to put my trousers and underwear on, and now I don't. And I can put my shoes on standing up. I mean, I have to use the longhorn, but I can, and I couldn't before – definitely couldn't.*" (ID16)

> "*That* [fitness] *and building my confidence in myself in my ability to walk and go up steps and my balance – my balance has improved heaps, you know. So, for me going, as I said before, going up steps now, I can walk up steps without hanging on. I still have to hang on when I'm coming down, but I have… yeah, so I just find I have a lot more confidence in going up and down steps*." (ID8)

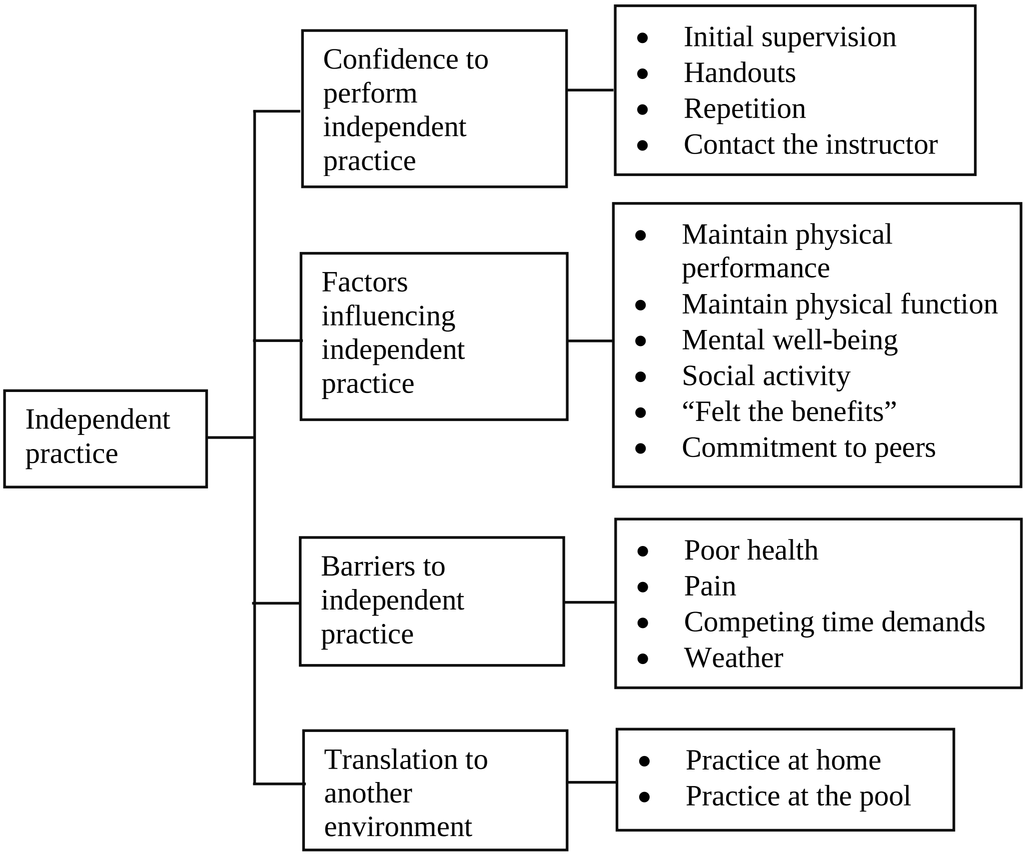
7.4.2.6 Barriers to attendance

Three barriers influenced the participants' attendance. The most commonly perceived barriers were poor health and competing time demands often due to medical appointments, family, or volunteer engagements. For example, "*I missed a few because I got vertigo and we had doctors' appointments and things of that nature. There's not much you can do about it in these conditions*." (ID13). A few of the participants also cited limited shade as a barrier to attendance during the summer months (i.e., over 30°C).

7.4.3 Independent Seniors Exercise Park practice

Ten participants (45.5%,) maintained once or twice a week self-practice training at the outdoors exercise park either with their peers or independently during the additional 6 weeks (weeks 19-24). Eight participants (36.4%) did a combination of self-practice training at the outdoors exercise park and another environment (home or pool), two (9.1%) did self-training at home, and two (9.1%) participants stopped doing any exercises due to pain from pre-existing conditions. Although participants reported the frequency of doing exercises, they did not complete the full duration of exercises recommended (i.e., two hours weekly). Four themes were identified relating to independent practice, these were confidence to perform training, factors influencing training, barriers to practicing and unexpectedly some participants transferred some of the exercises to new environments (see Figure 7.3).

Figure 7.3. Independent practice thematic map



7.4.3.1 Confidence to perform independent practice

All participants described feeling confident with continuing their independent training. This was because they perceived the instructions on how to use the equipment had been clear, repetitions undertaken during the supervised training had helped them to remember how to use the exercise stations, they also knew they could refer to the handouts with instructions about how to do the exercises, and if really necessary they could contact the instructor if they had any issues with their self-practice.

> *"Well, mainly because we've had good instruction; we know how to use all the equipment; I try and remember things like you know, how you should*

be standing, posture, you name it, and yeah. I've got no worries about it; nothing's unfamiliar, let's put it that way." (ID15)

"*Look, I think it's very confidence building and it's motivating to know that you're around* [option to contact the physical therapist] *and we can tap into your… you know, I mean, you might have to limit how often you're available but it would be nice to know that we could ring up and say, you know, I'm having trouble with my hip, which exercise do you think might be doing that*?" (ID19)

7.4.3.2 Factors influencing independent practice

Maintenance of physical function (e.g., ability to walk), physical performance (e.g., balance), mental well-being and "feeling" the benefits of exercise were reasons described by the participants as factors contributing to their independent practice in the six week self-practice phase of the intervention. For example, "*I'm feeling better fitness wise. I feel that I am quite fit now and I'm happy with that"* (ID4) and "*Trying to stay…keep the balance, the improvement that we've got I'd like to keep that*" (ID21). More than half continued exercising with their peers because they valued the social activity as a group and enjoyed chatting with peers or passersby. In addition, a few did not want to disappoint their friends since they made a commitment to turn up for self-practice.

"*Since we started doing this program…. we have developed quite a relationship within the group and we can support each other. And that's something that we've really all appreciated so that we have become quite a cohesive group. And if somebody can't come, they'll phone somebody and let them know. We've gone out to coffee together; we've really made quite* *a friendship group as well as an exercise group and that way that helps us to support each other to keep going*." (ID3)

7.4.3.3 Barriers to independent practice

Barriers such as competing time demands due to medical or family appointments and poor health were similar to those cited during the supervised component of the program. For example, "*Doctors' appointments, loads of them for* [spouse] *for his eye injection, neurology department, back to the doctor, emm… you know, it's just continual*" (ID21). Pain due to pre-existing health conditions (e.g., osteoarthritis) prevented a few participants from engaging in exercises. Extreme weather influenced many participants' practices at the park. Many of them did not go to the Seniors Exercise Park because of intolerance to heat during warmer days (i.e., 30ºC or above). One participant explained: "*It is just that I don't come, I won't come during the day in the summer because of the weather. Anything in the heat puts me off*" (ID24).

7.4.3.4 Translation to other environments

Participants used their own initiative and adapted the Seniors Exercise Park exercises to other environments (e.g., home or pool). Many participants practiced the exercises they learned from the Seniors Exercise Park at home by setting aside specific time to do the exercises or used their time for housework as an opportunity to do exercises. Participants used the wall or any stable supporting surfaces as a place to hold when required. Examples of exercises were tapping a foot on/off a step stool at home instead of tapping on/off the platform at the exercise park, and tandem walk down the hall at home instead of tandem walk across the balance beam at the exercise park.

> "*When I'm doing the dishes, I do standing on one leg to build up that ability to be able to balance on one leg. Umm… I do the leg exercises that we have,*

but I don't do them vertically; I do them horizontally. Umm… yeah, but I hadn't done those, I hadn't done them before we started. In fact, I was doing nothing at home, so these ones have just been incorporated into my movement around the house (every day)." (ID8)

Two of the participants incorporated a few of the exercises whenever they were at the pool (e.g., walk sideways, squats) because of the weather (e.g., hot) or it was more suited to their health condition (e.g., arthritis).

"*I have a routine now where some of it is holding onto a rope and I do a pipe or something on the side of the pool and just going up and down like I'm getting in and out of a chair for instance, doing that five or 20 times. Or standing on my toes 20 times; walking with crossing my feet.*" (ID19)

7.5 Discussion

To the authors' knowledge, this is the first study to explore perceived Seniors Exercise Park experiences of a supervised outdoors Seniors Exercise Park intervention transitioning to independent practice and perceived factors influencing their participation during supervised and independent training for people with mild balance dysfunction. These qualitative results complement the quantitative outcomes associated with this intervention (Ng et al., paper under review). The findings suggest that the Seniors Exercise Park program was viewed as an acceptable and positive approach for physical activity by older adults with mild balance dysfunction. Participants emphasized the importance of supervision by a health professional initially to meet the individual's needs, to learn how to use the exercise equipment correctly and to prevent injury. Participants perceived group training as an opportunity to build social connections. Many participants reported that the training program improved their physical and psychological health.

Various factors influencing attendance during supervised training and independent practice were identified. Our findings indicated that program structure (i.e., length and duration of the program) and content (i.e., challenging exercises, variety of exercises), individualization of exercises, positive personality of the instructor, and social aspects of the intervention were important factors influencing attendance during supervised training. Other studies have also found that having a well-designed program structure and content enhanced participation in exercise programs (Chiang et al., 2007; de Lacy-Vawdon et al., 2018; Tak et al., 2012). Individualizing exercises to the abilities and needs of the participants was perceived positively by the participants, which has also been reported in previous systematic reviews (Bethancourt et al., 2014; Franco et al., 2015). Therefore, it is recommended that practitioners who conduct exercise programs need to be knowledgeable about exercise prescription and adapt the exercises to the individuals' needs and abilities (Bennell et al., 2014; de Lacy-Vawdon et al., 2018).

Good instructor personality, such as being supportive and encouraging appeared to influence participants' attendance, which is similar to other physical activity programs (Bethancourt et al., 2014; de Lacy-Vawdon et al., 2018; Farrance et al., 2016; Franco et al., 2015). In a study by Burton, Hill, et al. (2017), older adults ceased participation in resistance training programs due to dissatisfaction with the instructor, illustrating how important this role is when working with older adults. During the early supervision phase of using the Seniors Exercise Park, the instructor provided support, guided and progressed the exercises in an individualized manner, and encouraged the participants; this is supported by previous research and may be viewed as essential factors for encouraging initial and continued participation (Burton, Hill, et al., 2017; de Lacy-Vawdon et al., 2018; Franco et al., 2015). Although the role of the instructor featured prominently during the supervised intervention, as expected, it was not emphasized during the independent practice because there was limited or no contact with the instructor in the latter period.

Social connectedness and feeling part of a group of likeminded people played an important role and appeared to influence the participants' experience in this novel physical activity program, similar to results found in previous group physical activity programs (Bethancourt et al., 2014; de Lacy-Vawdon et al., 2018; Farrance et al., 2016). Social connectedness and maintaining their gains in performance became increasingly important during independent practice. Living in a retirement village may enhance relationships and reduce social isolation and loneliness among residents (Yeung et al., 2017). Exercising in a group may reinforce relationship building when group members frequently meet for social reasons and physical activity outside supervised training. Social connectedness may help address issues with initiating physical activity and improve perceptions of safety (Thøgersen-Ntoumani et al., 2019) which may increase self-confidence to exercise. Although this study suggests that social connectedness is important, group-based training may not be the most suitable method to increase participation for some participants. There is some evidence from this study and others that some participants may prefer to exercise alone (Amireault et al., 2019) or with one other person (i.e., dyadic approach) rather than in a group (Carr et al., 2019). Community facilities and health professionals delivering group physical activity programs could emphasize social connectedness and may need to adapt their strategies and conversations to encourage independence and peer support in their programs for sustainability.

Some older adults used the outdoor exercise equipment incorrectly, potentially increasing their risk of injury (Chow & Wu, 2019). Participants in this current study perceived supervision as critical to learning how to use the exercise equipment correctly, safely, and effectively. These results suggest that local authorities or retirement villages might want to provide supervised Seniors Exercise Park sessions so that older adults learn how to use the outdoor exercise equipment correctly and safely.

Participants perceived many health benefits, including improvements in physical function, physical performance, confidence, and/or mental well-being. Positive health benefits were also perceived by community-dwelling older adults in a previous Seniors Exercise Park study (Sales et al., 2018). Importantly, half of the participants in this present study perceived improved balance, which is an important finding because this intervention targeted older adults with mild balance dysfunction, who were at risk of further declines in balance and were at an increased risk of falls. The results suggest the Seniors Exercise Park intervention has the potential to improve health, particularly balance, in older adults with mild balance dysfunction.

Participants suggested that the supervised sessions, repetition of exercises, provision of handouts, and option to contact the instructor if needed increased their confidence to use the Seniors Exercise Park independently. These results indicate that including these factors is important for implementing similar exercise programs in future (i.e., supervised intervention transitioning to independent practice).

Integration of exercises to older adult's lifestyle routines may enhance physical activity adoption and maintenance (Clemson et al., 2012; Opdenacker et al., 2008; Simmonds et al., 2016). An unexpected finding in our study was that more than half of the participants adopted the Seniors Exercise Park exercises in a different environment (i.e., home or pool). Increased self-efficacy or confidence and the perceived benefits of physical activity may have influenced many participants' desires to continue training at the Seniors Exercise Park, at home, or in a pool independently. Although social connectedness featured strongly as a theme during supervised training, integrating the exercises in the home or pool may address some participants' adherence to independent practice due to competing time demands.

Common barriers to regular Seniors Exercise Park use were poor health, competing time demands and extreme weather conditions (e.g., hot weather) which affected participation during supervised training and independent practice. A few participants reported pain prevented them from engaging in exercise during independent practice. These results aligned with Seniors Exercise Park (Levinger, Dunn, et al., 2021) and other exercise programs (Jansons et al., 2018; Tulloch et al., 2013). To address these barriers, exercise practitioners overseeing the Seniors Exercise Park program may want to work closely with the participants to identify strategies when they are at risk of not completing existing programs. In addition, organizations that install Seniors Exercise Parks in their jurisdiction should consider providing shade over the equipment to avoid it being a barrier to participation.

7.6 Strengths and limitations

This study had several strengths and limitations. This research is the first to provide an insight into the experiences of older participants with mild balance dysfunction taking part in a supervised Seniors Exercise Park intervention progressing to independent practice. In contrast to other research published on the use of Seniors Exercise Parks, the intervention involved a gradual reduction of therapist supervision to the point of independent practice, which is important in terms of sustainability of this type of approach in community settings.

The participants were recruited from a single setting and may not represent older adults with mild balance dysfunction across the community. The small number of male participants interviewed limits the diversity in the sample. Therefore, future studies need to explore how to increase the uptake of older males to the Seniors Exercise Park program and incorporate strategies to target older males with mild balance dysfunction, as well as older females to encourage participation. The responses of the participants may be influenced during the interviews because of how the questions were phrased (e.g., Were you able to find enough time to fit the exercise park into your week?), and the interviews were conducted by the same physical therapist who supervised the intervention and interviewed the participants, due to funding constraints of the project. There is always the risk that participants may have responded to the questions positively because they wanted to please or did not want to upset the researcher, rather than express what they experienced during the program. Future studies should consider engaging an independent researcher to conduct the interviews if adequate resources and funding are available. There is also the chance that researcher bias may be present. Steps to minimize bias were included by ensuring data saturation, gathering, and analyzing data simultaneously, including the notes taken during and directly after each interview, two researchers analyzed the data independently before coming together to discuss, and a third researcher verified the findings. Groups of participants entered the program at different times during the year, and therefore, weather conditions, social or family commitments may have affected their ability to attend supervised Seniors Exercise Park training or self-practice. Coronavirus lockdowns were also occurring on a semi-regular basis and at times may have affected participation and independent practice, particularly when mask wearing was mandatory. Mask wearing was mandatory for five weeks of the program.

7.7 Conclusion

Older adults with mild balance dysfunction expressed positive experiences after participating in this outdoor group Seniors Exercise Park program. Participants emphasized the importance of supervised training for using the exercise equipment correctly and safely. They perceived that group exercise created opportunities for social interaction and connectedness. Many participants perceived physical, social, and well-being benefits, and some integrated these exercises into their lifestyle routine at home and in the pool. Half of the participants perceived their balance improved, highlighting the potential of using Seniors Exercise Parks to improve balance in older adults with mild balance dysfunction. Addressing barriers is important to encourage participation during supervised training and independent practice. In addition, emphasizing facilitators such as having a high-quality instructor who is supportive and including opportunities for social interactions are important when improving existing or new Seniors Exercise Park Programs for older adults with mild balance dysfunction. The experiences of older adults with mild balance dysfunction undergoing the Seniors Exercise Park program may provide information to guide further research, practice, and policy.

Chapter 8 : Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic

Chapter outline

Older adults' participation in physical activity could have been affected during the COVID-19 pandemic. No studies had explored the impact of the pandemic on physical activity participation for older adults living in retirement villages. This published study aimed to fill this gap.

This is the peer reviewed version of the following article:

Ng, Y.L., Hill, K.D., & Burton, E. (2022). Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic. *Australasian Journal on Ageing, 41,* e103-e111, which has been published in final form at https://doi.org/10.1111/ajag.12963.

8.1 Abstract

Objectives: To explore physical activity changes and participation amongst physically active older adults living in retirement villages during the coronavirus (COVID-19) pandemic.

Methods: Semi-structured interviews were conducted over the telephone. The interviews were recorded and transcribed verbatim. Reflexive thematic analysis was conducted.

Results: Seventeen older adults were interviewed, and they engaged in many types of physical activity before the COVID-19 lockdown. During the COVID-19 lockdown, the most common physical activity that older adults participated in was walking. Mental well-being and socialisation were affected during the lockdown, with older adults employing several strategies to help them cope.

Conclusion: During the COVID-19 pandemic, physically active residents of retirement villages maintained their physical activity, but with reduced intensity and variety. In some cases, this impacted their mental and physical health. Physical activity resources aimed at facilitating diverse and sufficiently intense physical activity may benefit this group, and others.

Practice Impact: Older adults continued to engage in physical activity during COVID-19. However, the intensity and nature may have been insufficient to gain/maintain health benefits. Our findings may guide healthcare services and retirement villages to develop and implement integrated resources to promote adequate intensity and dose of physical activity during future pandemics.

8.2 Introduction

The 2019 coronavirus (COVID-19) was declared a worldwide pandemic on 11 March 2020 (World Health Organisation, 2020a). Older adults were identified as most susceptible to infection by coronavirus (COVID-19) (Heymann & Shindo, 2020) and were advised to practice physical distancing to minimise the risk of contracting COVID-19.

Physical distancing consists of minimising physical interactions between people (Wilder-Smith & Freedman, 2020; World Health Organisation, 2021b). Older adults practicing physical distancing may make changes to their lifestyle routines, including reducing the number of social activities they participate in outside the home and modifying or curtailing the type of physical activity (PA) they undertake during these periods of lockdown. Lockdown is defined as the enforcement of strict restrictions on social interaction, entry to public areas, and travel (Collins Dictionary, 2020). In addition, there are reduced opportunities to be physically active in organised group activities due to the closure of fitness and sports facilities. Consequently, these changes and the closure of facilities could increase sedentary behaviour among older adults. Sedentary behaviour increases the risk of depression (Huang et al., 2020), mortality, and major chronic diseases (Fox et al., 2014), therefore any reduction in PA could have negative effects for older populations during this pandemic.

A previous qualitative study revealed that attendance at a group-based PA program declined during the COVID-19 pandemic (Goethals et al., 2020). The authors also reported that older adults understood the necessity to continue PA at home while isolating and they were unaware and not interested in using online PA videos (Goethals et al., 2020). Therefore, there is a need to better understand if and how older adults continued to be physically active during this pandemic, identify PA that interests them while they are practicing physical distancing, and how they managed other constraints (e.g., closure of exercise facilities and cancellation of group PA) associated with COVID-19 restrictions.

Some older adults choose to live in retirement villages as they age. An estimated 5.7% of Australians aged above 65 years have transitioned to live in a retirement village (Property Council of Australia, 2014). A retirement village is a housing environment built to support older adults who are generally independent with easy access to social activities and communal facilities (e.g., hall) (Property Council of Australia, 2014), and on site security. Exploring residents' perspectives and experiences will help us understand how they can be better supported to live healthy and independent lives should another pandemic arise. Limited research to date has focused on understanding the experiences of older adults during the pandemic and the impact it has had on their PA participation. Therefore, the present study aimed to explore the PA experiences of older adults living in retirement villages during a pandemic (COVID-19).

8.3 Methods

The COnsolidated criteria for REporting Qualitative research (COREQ) which consists of 32 criteria designed for interviews (Tong et al., 2007) was followed when reporting the findings of this study.

8.3.1 Study design

This was an exploratory qualitative study that took a phenomenological approach using semi-structured interviews (Carpenter, 2013). The underlying focus of our study was to explore the lived experiences of older retirement village residents and how COVID-19 has affected their PA experiences.

8.3.2 Participant recruitment and study setting

Participants were recruited from a convenience sample of older adults who lived in two retirement villages in Perth, Western Australia, who had participated in a previous research (validation) study and gave approval to be contacted for participation in future research. The recruitment process was completed by the lead researcher, NYL from 4th June to 24th June 2020. Participants were contacted by phone and if they were interested in participating, they received further information about the research (i.e., information sheet including a summary, purpose, and reasons for doing the research) via e-mail. Participants sent back a statement of consent to confirm voluntary participation if they were interested, and the date for an interview was arranged. Inclusion criteria were: adults aged 65 years and above, able to ambulate independently with or without a walking aid (self-reported), able to understand and speak English, and participated in at least 30 minutes of moderate intensity PA on at least two days a week before the COVID-19 outbreak. In addition, because of recruitment being linked to the previous retirement village study, all participants were living in retirement villages.

8.3.3 Data collection

All interviews were conducted over the phone due to government recommended COVID-19 restrictions, and the conversations were audio recorded. Demographic data were collected, and an interview guide was used to lead the initial questions; where required additional questions were asked (see Appendix 14). The interview questions were presented in everyday language, were easy to understand and were rephrased when required. Written comments were also made by the researcher during the interview. Interviews were conducted until no new information was obtained (i.e., saturation), this was estimated as likely to occur between 16 to 24 participants (Hennink et al., 2017). Steps were taken to minimise researcher bias including proper sequencing of the questions asked (i.e., general questions were asked first followed by more focused questions about COVID-19), avoiding using words or asking leading questions that could initiate bias, asking questions using neutral tones, and analysing all the data collected. NYL was supervised by EB, an experienced qualitative researcher throughout the data collection process. None of the researchers had any role or occupation at the retirement villages.

8.3.4 Ethical considerations

Curtin University Human Research Ethics Committee approved the research (Approval number: HRE2020-0271). All participants provided a statement of consent sent through e-mail, and consent to participate was also audio recorded before participation in the study.

8.3.5 Data analysis

Two independent researchers used Braun and Clarke’s six phases of reflexive thematic analysis to analyse the data (Braun & Clarke, 2019; Braun et al., 2021). Reflexive thematic analysis was selected because it is a suitable method of sharing the content of the interview, identifying patterns of the data and presenting interpretation of the data (Lynass et al., 2012). An inductive approach was adopted whereby the analysis was based on the “meanings in the data” (Clarke et al., 2015). Each interview transcript was read and re-read to increase familiarisation with the data. Data were transferred to Excel to assist in the display of data and to easily examine patterns (Bazeley, 2021). Relevant words and phrases were highlighted across each interview and then allocated a relevant code. Codes with the same meaning were then grouped to form themes. These themes were organised into sub-themes. To improve trustworthiness, the findings from the two researchers were compared and collated before being sent to a third researcher for review (Shenton, 2004). A concept map was developed to understand the relationship amongst the themes in relation to the research question using Draw.io online diagram editor. Concept maps are used to organise concepts (in this case the themes) and establish relationships between concepts (Novak & Alberto, 2007). All authors provided feedback and adjustments prior to confirmation of the concept map.

8.4 Results

8.4.1 Participant demographics

Nineteen participants were contacted. Two participants declined to participate due to lack of interest. Seventeen participants were interviewed and reached data saturation. The duration of the interviews ranged from 13 to 54 minutes. The characteristics of the participants are shown in Table 8.1.

Table 8.1. Characteristics of participants

Variable	**Participants (n=17)**
Age [M (years) (SD)]	75 (4) years
Sex [male n (%) : female n (%)]	5 (29%) : 12 (71%)
Highest Education level attained [n (%)]	
High school	9 (53%)
Higher education (University and others)	8 (47%)
Living arrangements [n (%)]	
Home alone	7 (41%)
Home with partner	10 (59%)
Self rated general health [n (%)]	
Poor	0 (0%)
Fair	0 (0%)
Good	5 (29%)
Very good	8 (47%)
Excellent	4 (24%)

Note. M = mean; SD = standard deviation; n = number of participants; % = percentage; PA = physical activity.

8.4.2 Reasons for doing PA

Participants talked about the importance of PA participation to their lives. More than half of the participants were physically active to maintain their health and fitness. '*We know that we've got to keep moving, if we don't you're just going to sleep and fade away, that's sort of a motivation I suppose, and the other motivation is that the healthier, the fitter you are, the less likely you are to get other stuff or things wrong with you'* (Participant 6) and '*It's very important for physical health and for mental health'* (Participant 14).

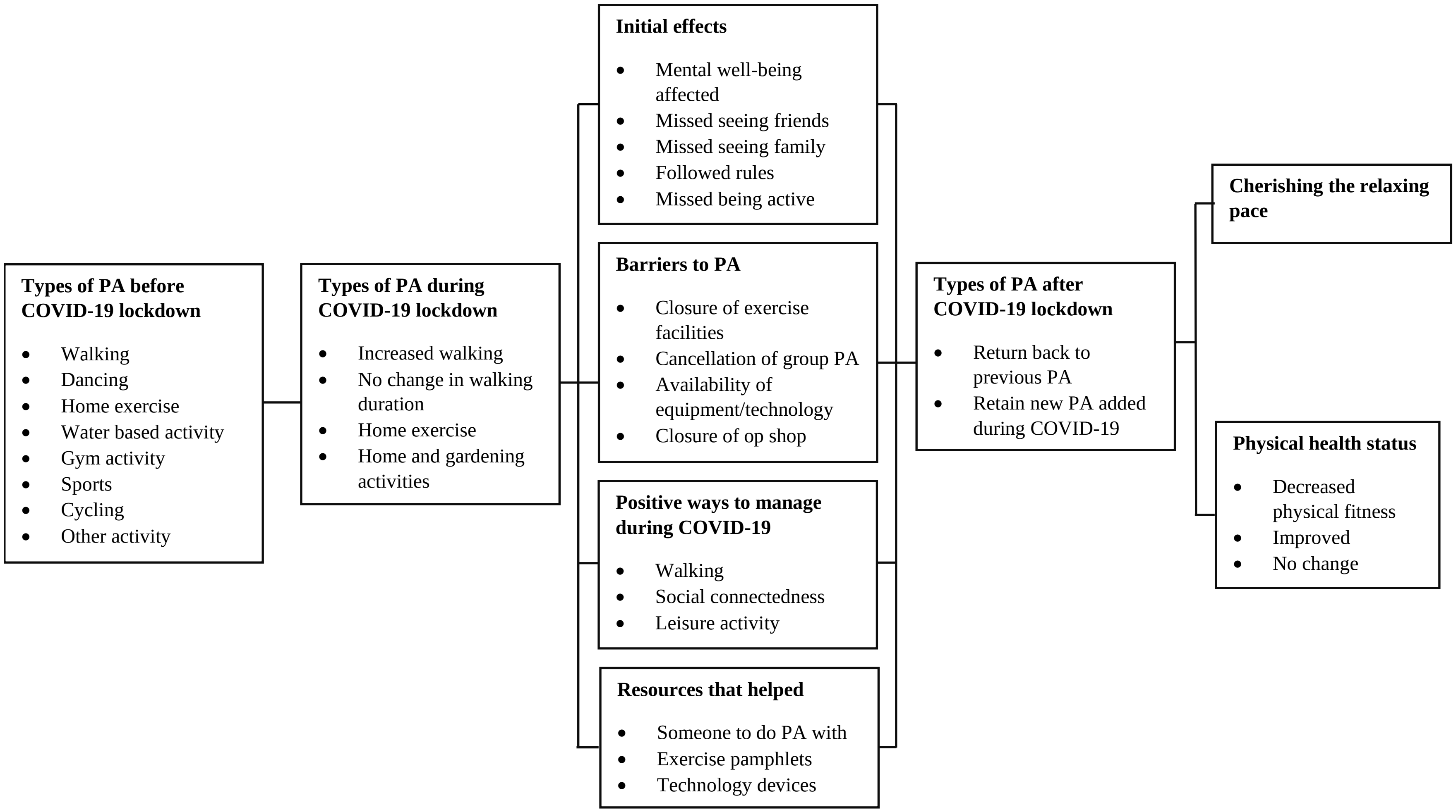
A few participants undertook PA to maintain their weight. *'I don't want to put on a lot of weight'* (Participant 5) and *'I really need to do, not strong exercise but some exercise, to keep my weight down'* (Participant 15) while others emphasised that performing PA helped to maintain their functional independence. '*It means being able to do things, go out walking, stay at home and do what I need to do at home'* (Participant 4) and '*To keep myself more agile so that I don't fall over*' (Participant 11).

Positive experiences were reasons for ongoing engagement in PA. Many expressed enjoyment while performing PA. '*It's a way of keeping healthy. I enjoy the walking and the exercise generally and mostly it's just to maintain my health levels*' (Participant 3) and '*I enjoy activities because I usually do them outside, in the fresh air*'. (Participant 11). Some spoke about 'feeling good' after completing their PA. *'I found it really make*s *me feel happier and I felt my body felt stronger'* (Participant 2) and *'PA is very important to me. I always feel good after I have done PA'* (Participant 1).

8.4.3 Concept map

A number of themes and sub-themes were developed from the interview data (see Figure 8.1).

Figure 8.1. Concept map



Note. PA = physical activity; COVID-19 = Coronavirus.

8.4.4 Types of PA before the COVID-19 pandemic

Walking was the most common type of PA performed by all the participants. In addition to walking, all participants performed different types of PA each week (see Table 8.2). The different types of PA included aerobic PA such as water-based activity or cycling, many also participated in strengthening exercises at the gym. Some of the participants performed PA alone such as home exercises or in a group such as dancing.

Table 8.2. Types of PA before the pandemic

Sub-themes	Quotes
Walking	I go for a walk through the village which could take anything from 20 minutes to an hour (Participant 9)
Dancing	Line dancing once a week here in the auditorium, and then before covid, we were going dancing every Thursday evening at a hall, that's new vogue dancing, which is like English sequence dancing (Participant 6) I've enjoyed the social side of physical activity with other people such as line dancing (Participant 16)
Home exercise	I wake up in the morning, I do about 20 minutes or so of exercises mainly stretching and flexibility exercises (Participant 1) I do a little bit of weight lifting but not for very long (Participant 10)
Water based activity	I go with my two neighbours. Do a little bit of swimming, but mainly walking (Participant 17)
Gym activity	Before the pandemic, I went to the gym three times a week (Participant 13)
Sports	Play table tennis for with [husband] and myself for about 50 to 60 minutes a a day (Participant 8) Croquet, though I don't know if you call it that. You hit the ball with a mallet from a hoop (Participant 5) I just did the lawn bowls (Participant 2)
Cycling	Cycling is, we stay in the same suburb, we just go cycle around (Participant 12)
Other activity	The op shop might. That's because I am lifting something (Participant 4) I deliver the mail around the village it's walking but it's a regular activity and that's usually about between half an hour each week (Participant 6) I do all the housework …mostly I do most of the housework, vacuuming, mopping the floors or that I do the cooking to me that's all activity (Participant 11) But if I go to the workshop, I um, there's all sorts of things I do in the workshop. I'll be changing tyres on the car or changing the oil on the car or greasing up the car or and all that sort of physical stuff (Participant 12) I do gardening, I water my garden most mornings (Participant 14)

8.4.5 Types of PA during COVID-19 lockdown

All participants continued their outdoor walking and could walk with one other person during the lockdown, however they needed to physically distance while walking (i.e., walk 1.5 meters apart). Almost half of the participants increased their duration of walking:

> '*During that time and during the lockdown, because we had more time we were walking probably twice a day so we did more walking, during the shutdown because we weren't having to go, we go each afternoon to pick our grandchild from school so instead of doing that we go for another walk*' (Participant 6).

A few of them took up home exercises:

> '*I've actually made or saved two litres of milk cartons you know those plastic bottles two of them I filled up with yellow sand and the other two I fill up with water and I actually use those as weights to do my upper body arm exercises*' (Participant 9).

A few participants did home and gardening activities. '*Keeping active like keeping busy within the house or outside'* [housework and gardening] (Participant 11). All other PA was stopped due to cancellation of group PA (i.e., dancing) and closure of leisure or exercise facilities such as water-based PA, sports, gym and the opportunity shop ("op shop") (i.e., a shop selling second hand goods operated by participants for charity).

8.4.6 Initial effects of being in lockdown

Decreased mental well-being was a commonly mentioned effect of the COVID-19 lockdown for these participants. Words used to describe their feelings were 'caged up', 'concern and worried', 'isolation', 'restricted', 'shut us out', 'prisoner in your own home', 'go mad', 'lonely' and 'boring'. One participant said '*A little bit, probably* *mentally and, mentally, on it, caged up inside. We're not used to being caged up inside all the time and staying home all the time*' (Participant 4). Most participants also missed seeing their family; '*I would love to see my grandchildren and my children*' (Participant 2) and friends (including friends who they do group PA with):

> '*After prime movers… sometimes some of us ladies go and have a coffee at the park centre. We go and have a coffee together at the café….so, not doing that, I don't like not doing that because I missed, I have missed the social interaction with the other ladies*' (Participant 7).

Following government rules were important to some of the participants:

> '*Well, at the beginning of the COVID, we were all told to stay in your home and being a good citizen that's what I did. I might've gone outside into my veggie garden, but I might've stayed at home and not even going for walks*' (Participant 9).

A few of the participants missed performing PA:

> *'Not walking at all was really hard. Even the days that we have, now when it's raining. It's really hard. I sort of missed the walk. Because we have gone into the routine of doing this walk everyday now. It's really good. Whereas, before, we thought well, it doesn't really matter, it matters somehow. I don't know why* (Participant 4).

The effect of not being able to undertake PA they were previously doing before COVID-19 appeared to be less of a concern to the participants because (i) they were doing other activities at home; '*We make sure that I kept busy, we sorted a lot of old paperwork and we sorted other things and I caught up on some sewing and things like tha*t' (Participant 11), (ii) some of them increased their duration of walking; '*Well the walking, during COVID, I started doing a lot more walking. Then I started walking* *with a friend in the building. If I go with her, we do a long walk, usually 10,000 steps*' (Participant 1) and (iii) a select few took up other types of PA such as home exercise; '*I was feeling a bit sad or miserable you know and then as soon as I introduced my exercise [home exercise] because I heard it then a lot of times that exercise was good you know for your well-being, and then as soon as I started exercise, I felt good as I used up some energy that I have, so it's really improved my well-being, that's definitely so*' (Participant 2).

8.4.7 Barriers to being physically active

The commonly cited barriers to participating in PA were:

(i) closure of exercise facilities; '*I couldn't do the pool because it was closed*' (Participant 17),

(ii) cancellation of group PA; '*Prime movers came to a stop… and we were not allowed to go and play table tennis, dancing also stopped'* (Participant 7) and,

(iii) lack of technology or equipment '*The exercises I do at home are fine, but they are not the same as doing it at Fremantle. Well, obviously the machinery that you use, I haven't got in the house here, but mostly it's available at Bentley and in the gym there*' (Participant 3).

8.4.8 Positive ways to manage during COVID-19

There were numerous strategies participants undertook to help them feel better during the height of the pandemic. The majority cited **walking** helped them evoke positive emotions. '*At the beginning, I thought they would try to confine over 65s at home and I used to creep out early and do my walks, so I didn't… I kept it up I thought I'd go mad otherwise'* (Participant 10). Another popular strategy was maintaining **social connectedness** with their friends and family. '*If we have a cup of coffee with the* *neighbours, we all sit, we have been sitting in our driveways and a metre and a half apart'* (Participant 11). Some participants pursued their **leisure activity** at home. *'I did lots of sewing, made a couple more rugs, did cross stitch and quite a lot of crafts, crafty things that you don't get a lot of time for otherwise'* (Participant 6). Leisure activities are activities pursued for pleasure, and some examples provided by the participants were dot the dots, sewing, patchwork, and reading.

8.4.9 Resources that helped during COVID-19

Some of the resources that helped the participants to continue being physically active were:

(i) someone to do PA with; '*I walked because my partner is far more disciplined, so I walked with him and once I've done the walk I feel much better*' (Participant 11),

(ii) provision of exercise pamphlets from health professionals; *'Book was called "Encouraging People Aged 65 Years and Over to Participate in Strength Training" and it's got the workout menu from home and I found that this was invaluable for me, to be honest*' (Participant 2) and,

(iii) technology devices such as wii and fitbit; *'I think the wii is excellent, because it's fun and ……especially the things like tennis, when I was playing against the wii, it used to knock me right out. Really puffing after. I think the wii is excellent, although I presume there's other things like the wii that you can do*' (Participant 3).

8.4.10 Types of PA after the COVID-19 lockdown

There were mixed responses by the participants about their future plans. The majority of the participants suggested they would embark on all the PA they were previously doing before the lockdown. '*Go back to doing the same things [table tennis, cycle, dancing, line dancing, walking]*' (Participant 8). A few also suggested they would keep doing the PA they added as well. '*Just doing the bowls, but I just want to keep doing the exercise [home exercise] because I could feel the difference that is, the well-being for me*' (Participant 2).

8.4.11 Cherish the relaxing pace

Over a third of the participants enjoyed the time they had to themselves at home and they felt the pace of life had slowed also. Some of the words used to describe their emotions with their newfound pace were 'peace and quiet', 'happy to stay at home', 'refreshing and relaxing', 'don't have to be out and about all the time', and 'relaxed'. One participant said:

> '*I think I'm a little bit stressed over, a bit less stressed over deadlines. I find that before the pandemic I must do something by, I must have my breakfast early in the morning, I must be up and ready early. Now, I'm a lot more relaxed than with those types of time. Although I'm retired and it didn't matter really, but I think all the years of having to be ready and early. I've now shed that a little bit, I now take a cup of tea back to bed and read the paper which I would never dream of doing before*' [laughter] (Participant 16).

8.4.12 Physical health status

There were mixed comments about the effects of the COVID-19 lockdown to the health of the participants. Almost half of the participants noted that there was no change to their physical health. '*No, I didn't notice any change at all*' [physical health] (Participant 6). Over a third of the participants described a decrease in their physical fitness such as strength, endurance, flexibility or energy levels. '*Well, I know when I got back to tennis I wasn't as sharp*' [laughter] (Participant 5). A small number of participants emphasised that their physical health improved. They substituted their usual PA with exercises they could do on their own such as home exercises, and increased the duration of walking and frequency of stair climbing to maintain their fitness. '*It definitely improved my balance a lot and I can feel it and I also have a little bit of sciatica on my left side and that actually seems to have gone since I started the exercises* [home exercise]' (Participant 2).

8.5 Discussion

The findings of this study indicate that older adults followed public health advice during COVID-19 and performed PA when it was safe to do so while adhering to physical distancing recommendations. This concurs with a previous study reporting older adults performed some PA during lockdown (Brown et al., 2021).

Participants recognised PA as important to maintain health and fitness, weight and evoking positive experiences. The participants perceived benefits of PA could explain their behaviour of continuing their PA during COVID-19 lockdown, and could be supported by the health belief model. The health belief model is one of a number of models proposed to explain the factors influencing maintenance and change of health behaviour (Champion & Skinner, 2008). One of the factors was that an individual's beliefs regarding the benefits of their actions (in this case the benefits of PA) will influence their behaviour, which aligns with the finding of our study (Champion & Skinner, 2008).

All participants engaged in light or moderate intensity PA such as walking, gardening or housework during COVID-19 lockdown. Due to the cancellation of group activities or closure of exercise or leisure facilities they engaged in fewer formal PA options and over a third of the participants commented that there was a reduction in their physical health (i.e., strength and fitness) after COVID-19 lockdown. This seemed particularly noticeable for those that had participated in strength training at a gym. This suggests that the intensity and nature of PA performed by participants during lockdown may have been insufficient. It also appeared that the majority of participants did not do enough multimodal types of PA (i.e., balance, resistance, and cardiovascular) as recommended by the Australian PA guidelines (Sims et al., 2010). Therefore, should another pandemic arise it is recommended that resources and public health messages focus on (a) assisting older adults to engage in sufficient intensity and a variety of PA or exercise to maintain their health and fitness and (b) introducing additional health promotion campaigns to encourage older adults to be physically active.

The majority of participants stated that their mental well-being and social connectedness were affected (i.e., missed seeing their family and friends face to face). Older adults surveyed in the United Kingdom also reported missing face to face contact (Brown et al., 2021). However, participants appeared to be resourceful and coped well by employing a variety of strategies. Increased internet use via chat software such as Skype during the pandemic (Nimrod, 2020) may have helped participants maintain social connectedness. Going for walks with others while still physically distancing may also have helped promote better mental well-being (Kelly et al., 2018) among the participants. In addition, performing PA outdoors can improve mood (Matsouka et al., 2010) and there are potential benefits associated with sunlight exposure (i.e., source of vitamin D) (ten Haaf et al., 2019). Engagement in leisure activities improved the mental health of the older adults (Everard et al., 2000), although not offering the same physical health benefits as PA.

A number of resources helped the participants to continue being physically active during the pandemic. Support from another person was an important motivator for PA before the pandemic (Miller & Brown, 2017) and appeared to continue motivating the participants (i.e., the current study) during COVID-19. Exercising at home has been suggested to minimise the health consequences of sedentary behaviour during the pandemic(Lakicevic et al., 2020) and was noted by a few of our participants. In addition, exploring and promoting a diverse range of PA opportunities that are available, even within the constraints of a pandemic are important in maintaining PA (Levinger & Hill, 2020b). There have been a number of websites and other resources that have been developed during the pandemic to support older adults to take up and continue PA that are covid-safe. These are primarily within the home environment, and also cover issues of safety during PA, motivation, starting levels for exercise, and exercise progression (https://safeexerciseathome.org.au and https://facebook.com/SielBleuIreland). There have also been suggestions of increased PA participation through some of the media messaging to maintain health (e.g., one of the main reasons for being allowed outdoors was for exercise in some jurisdictions) (Levinger & Hill, 2020a). These findings offer valuable insights to retirement village managers and local governments about the type of health promotion resources that may support older adults during a pandemic.

An interesting finding of our research was that over a third of the participants valued the time they spent at home during COVID-19, that their pace of life was reduced, and that this was perceived as a positive outcome. This result may be due to reduced family expectations (i.e., picking up grandchildren from school) and more time to pursue their hobbies at home such as reading during the COVID-19 lockdown. This has not previously been described in other research investigating PA in older people during a pandemic and may need to be explored in future research, from both a physical and mental health perspective.

The findings of this study provide valuable insights about the experiences of a group of older adults who were generally physically active before COVID-19 and managed to continue being active during the pandemic. Further research is needed to explore the PA experiences of older adults who are frailer or less active and how they responded to lockdown and maintaining PA. It remains an important goal for researchers and practitioners to find approaches that encourage more older people to meet PA guidelines regardless of their health status. This may include having information and resources readily available to support PA participation during challenging times such as pandemics.

8.6 Strengths and limitations

The strength of this study is that we interviewed older adults who were actively engaged in different types of PA before and during COVID-19. One of the limitations of this study was the lack of diversity in the sample recruited and that older adults living in a retirement village may encounter different issues to older adults living in the wider community. Data saturation was met, however, findings could differ for those less physically active prior to or during COVID-19. The phrasing of the questions about the effects of COVID-19 on physical and mental health may have influenced the participants' answers during the interview. In addition, not using a standardised questionnaire (such as Physical Activity Scale for the Elderly (PASE)) to measure PA intensity, types and duration limited us from quantifying and comparing our findings with other studies.

8.7 Future research

Future research should explore the experiences of older adults living in their own homes in the wider community, particularly in those who are living alone, those who are frail, and or, those who are sedentary or underactive, because they may have differing needs, and require different supports or resources during a pandemic.

8.8 Conclusion

Although not as intense or of the same variety prior to lockdown, older adults continued engaging in PA during the pandemic while practising physical distancing and following public health recommendations. If pandemic-related lockdowns persist or occur again in the future, our findings indicate the potential value of promoting a variety of sufficiently intense PA that can be undertaken within the home to maintain physical and mental health and fitness. It may be beneficial for retirement villages and/or healthcare services to consider developing resources collaboratively with their residents and/or older adults in the community that meet the needs of the older person (e.g., incorporating types of PA that can be performed with another person, home-based) and the recommended PA targets (e.g., variety, intensity and dose). This would facilitate PA to continue through any future pandemics and cater to all stakeholder needs.

Chapter 9 : Discussion and conclusion

Chapter outline

This thesis consists of a series of studies using various research methods, including a systematic review, quantitative and qualitative research methods. A summary of the findings, including clinical implications, strengths and limitations, and recommendations for future research are discussed in this chapter.

The nationwide lockdown in Australia occurred during the second year of this PhD study. The lockdown and pandemic restrictions delayed the commencement of the Seniors Exercise Park intervention study (studies in Chapters 6 and 7) by six months. However, this delay provided an opportunity to include an additional study that explored the physical activity experiences of older adults living in retirement villages during a pandemic, including lockdown (Chapter 8).

9.1 Discussion of findings

In general, older adults do not engage in adequate physical activity to gain health benefits. To improve physical performance and prevent falls, multi-modal activities, including balance and strength activities need to be included. Novel approaches such as outdoor exercise parks can provide multi-modal activities for older adults in a single location. One group that could benefit from early preventive intervention (i.e., using Seniors Exercise Parks) are older adults with mild balance dysfunction.

The first study, a systematic review (Chapter 4) was conducted to evaluate the use and effects of outdoor exercise parks on older adults (Ng, Hill, Levinger, et al., 2021). The review included nine studies (i.e., three RCTs (Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Sales et al., 2017), three cross-sectional (Chow et al., 2017; Cunha et al., 2019; Salin et al., 2014) and three qualitative studies (Chow, 2013; Chow

& Ho, 2018; Sales et al., 2018)). The results confirmed that older adults used outdoor exercise parks to maintain and/or improve health and provided opportunities for socialisation. These results tie in with a previous systematic review reporting that individuals used outdoor exercise parks for health and social reasons (Lee et al., 2018). Findings from individual RCTs showed that outdoor exercise parks improved some physical performance outcomes. However, when the RCTs were pooled for meta-analysis, the results revealed no significant effects of outdoor exercise park training on lower body strength and balance. This could be due to the limited number of RCTs, lack of common outcome measures, and variety of outdoor exercise equipment used. These results corroborate with the findings of a systematic review of outdoor exercise park studies, which included individuals of all ages (Jansson et al., 2019).

A potential problem of evaluating intervention-related changes in higher functioning older adults is the lack of responsiveness at the upper end of some outcome measures selected for evaluation, known as ceiling effects. The CBMS has been shown not to have ceiling effects, but it does require a large space and a flight of stairs for some assessment items, which may not be available in some older adults' homes. This lack of ceiling effects was particularly relevant for the planned Seniors Exercise Park study (Chapters 6 and 7), which aimed to target people with mild balance dysfunction. Therefore, the second study (Chapter 5) validated a modified assessment tool (CBMS-Home) developed to discriminate the performance of independent, community ambulant older adults in settings with limited space. A number of measurement properties of the CBMS-Home were investigated. The results of this study (Ng, Hill, Jacques, et al., 2021) showed the following:

- CBMS-Home demonstrated good measurement properties (i.e., excellent test-retest and inter-method reliability, high internal consistency, similar number of three components on the principal component analysis and moderate to almost perfect agreement) when compared to the original CBMS.

- The CBMS-Home did not exhibit ceiling effects, similar to the CBMS (Ng, Hill, Jacques, et al., 2021). None of the participants received maximum scores on both the CBMS-Home and CBMS. This study concurred with the results of previous studies that the CBMS demonstrated minimal ceiling effects in independent community ambulant older adults (Balasubramanian, 2015; Weber et al., 2018).
- The minimal detectable change values for CBMS and CBMS-Home among independent older adults living in the community were determined in this study, which had not been reported in previous validation studies of the CBMS (Balasubramanian, 2015; Weber et al., 2018). The minimal detectable change values established in this study may be useful for physiotherapists and other exercise practitioners to determine whether exercise-related interventions aiming to improve balance and mobility have resulted in a reliable and real change in balance and mobility performance in their clients or patients.

In summary, this study demonstrated that the CBMS-Home had good measurement properties and was accurate in evaluating balance and mobility performance relative to the CBMS. These findings support the use of the CBMS-Home as a useful physical performance assessment tool, especially where environmental constraints of many homes (i.e., flight of stairs) may limit the use of the CBMS. Given the findings of this study, the CBMS-Home was selected as an outcome measure for the subsequent pre-post Seniors Exercise Park intervention study (Chapter 6) to evaluate balance and mobility in older adults with mild balance dysfunction.

From a health prevention perspective, there is a need to intervene early when older adults’ balance dysfunction is still mild, rather than waiting for balance to deteriorate to a visible and advanced level (Yang et al., 2011). Several studies support the use of exercise for older adults with mild balance dysfunction (defined using any description and inclusion criteria described in Table 2.4) (Nnodim et al., 2006; Rezaei et al., 2021; Sinaei et al., 2016; Williams et al., 2015; Yang et al., 2012), but none have examined the effects of a novel Seniors Exercise Park intervention in older adults with mild balance dysfunction. This type of outdoor exercise equipment is starting to become more commonly located in community parks in Australia.

Another novel aspect of the intervention approach used in this study was to gradually reduce health professional supervision during the initial 18 weeks. In the relatively small number of previous studies evaluating Seniors Exercise Park interventions, health professional supervision has been used for all sessions in their main intervention period (Levinger et al., 2020; Sales et al., 2017). This placed fixed time demands on the participants and is resource-intensive in terms of cost and sustainability. Older adults who are independent may not require ongoing, continuous supervision throughout 18 weeks.

Therefore, a quantitative study (Chapter 6) investigated the feasibility (including safety and effects) of a Seniors Exercise Park program with gradually reducing level of health professional supervision (weeks one to 18) transitioning to six weeks of unsupervised, independent practice (weeks 19 to 24) for older adults with mild balance dysfunction (Ng, Hill, Levinger, et al., 2022). In addition, a qualitative study (Chapter 7) explored the experiences of participants undergoing the Seniors Exercise Park program (weeks one to 18) and unsupervised, independent Seniors Exercise Park practice (weeks 19 to 24) and the factors influencing their participation and unsupervised independent practice. The quantitative (Ng, Hill, Levinger, et al., 2022) and qualitative findings of both studies are integrated in the context of other research and discussed below.

The Seniors Exercise Park program approach used in this research is feasible in older adults with mild balance dysfunction

The feasibility of this program was evaluated using the domains recommended by Bowen et al. (2009):

- *Demand*: There was sufficient interest in the program, whereby this study managed to recruit 46 residents from a single retirement village, even though it was conducted during the COVID-19 pandemic.
- *Implementation*: All 22 supervised sessions were completed within 18 weeks, although 14.3% of sessions were cancelled due to extreme weather (e.g., rain or heat). This result is consistent with other Seniors Exercise Park studies, and suggests that the program is implementable throughout different seasons (i.e., summer, autumn, winter, and spring) and regions of Australia with different weather patterns (Perth in Western Australia, and Melbourne in Victoria (Levinger et al., 2020; Sales et al., 2017)).

  Adherence to supervised training was higher compared to previous studies of Seniors Exercise Park programs for older adults (Levinger et al., 2020; Sales et al., 2017). Important facilitators from the qualitative component of this study encouraging participation during supervised training were the instructor's ongoing encouragement and supervision, the opportunity to interact with their peers during training sessions, and perceived benefits to health. These facilitators are consistent with the existing literature for Seniors Exercise Parks (Levinger, Dunn, et al., 2021; Sales et al., 2017) and the findings of previous systematic reviews on older adults engaging in balance and strength activities (Cavill & Foster, 2018), physical activity (Franco et al., 2015; Spiteri et al., 2019) and group-based exercises in the community (Farrance et al., 2016).

- *Practicality (including safety)*: Over three-quarters of participants with mild balance dysfunction and various chronic health conditions met the prescribed dose of exercise and completed the 18 weeks supervised Seniors Exercise Park program. Participants were able to perform the exercises individualised to their abilities with supervision, and after that independently.

  The Seniors Exercise Park program was safe with initial supervision by a physiotherapist, with no adverse events occurring in this cohort of older adults with mild balance dysfunction during the supervised and unsupervised sessions. This finding concurred with previous research that supervised Seniors Exercise Park training was safe among older adults who have concerns about falls or had one or more falls in the last 12 months (Levinger et al., 2020; Sales et al., 2017).

- *Efficacy testing*: The physical performance (e.g., balance and mobility, lower body strength, walking speed, physical activity levels), psychosocial (e.g., falls efficacy, exercise efficacy, mental well-being, and loneliness), and quality of life outcomes improved significantly following the Seniors Exercise Park intervention in older adults with mild balance dysfunction from baseline to 18 weeks and 24 weeks respectively. Previous studies also demonstrated that community-living, ambulant older adults improved their physical performance (Chow et al., 2021; Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Levinger et al., 2020; Sales et al., 2017), mental well-being (Levinger et al., 2020) and quality of life (Leiros-Rodríguez & García-Soidan, 2014; Levinger et al., 2020) outcomes following outdoor exercise park training intervention.

  Participants' in the qualitative Seniors Exercise Park study perceived improvements in daily activities (e.g., ability to put on trousers while standing), physical performance (e.g., balance, strength) and psychosocial outcomes (e.g., confidence while walking), with these findings supported by previous qualitative research in independent, community ambulant older adults (Sales et al., 2018). In summary, both quantitative and qualitative results demonstrated that the Seniors Exercise Park intervention can improve the health outcomes of older adults with mild balance dysfunction.

- *Adaptation*: The participants adapted well to the training and modifications made to the Sales et al. (2015) protocol (e.g., cuffed ankle weights instead of resistance bands for hip strengthening exercises). More than half of the participants in this study integrated the Seniors Exercise Park exercises (e.g., tandem walk, sit to stand exercise) into another environment (i.e., home and/or pool). This integration of Seniors Exercise Park exercises into other environments has not been reported in previous outdoor exercise park studies (Chow et al., 2021; Kim et al., 2018; Leiros-Rodríguez & García-Soidan, 2014; Levinger et al., 2020; Liu et al., 2020; Sales et al., 2017).
- *Acceptability*: The program was acceptable, and most participants reported they were satisfied with the program. The participants reported they were satisfied and enjoyed working with the instructor, they liked the health benefits they gained and the social experiences during the supervised training. These findings were similar to those in previous Seniors Exercise Park studies (Levinger, Dunn, et al., 2021; Sales et al., 2018).

Participant retention, adherence to independent practice, and conducting an outdoors exercise intervention during a pandemic are a challenge

Participant retention was a challenge in this study and is commonly reported in other physical activity programs involving older adults (El-Khoury et al., 2015; Iliffe et al., 2015; Jansen et al., 2021). Eight (17.4%) participants dropped out because of health problems (i.e., medical problems, pain, and physical injury), and two (4.3%) withdrew due to lack of time at 18 weeks. This percentage was higher than previous outdoor exercise park studies (Chow et al., 2021; Kim et al., 2018; Levinger et al., 2020; Liu et al., 2020; Sales et al., 2017). Although participants' health was screened using PARQ+ and doctor's clearance was provided by the participants when required, changes to participants' health or physical condition during an intervention program can be unavoidable. Therefore, to support these participants, it is recommended that practitioners overseeing Seniors Exercise Park groups reinforce to participants with new or exacerbated health problems that these interruptions to the program are often temporary, and that when they return, the practitioner will reassess their status and ensure their resuming level of exercise is appropriate for their stage of recovery. This might see a higher number of participants returning to the program, once they have recovered from their health or physical condition/illness.

Adherence to unsupervised, independent practice was low (Ng, Hill, Levinger, et al., 2022). Participants reported health problems, lack of time due to family or medical appointments, pain due to pre-existing medical conditions and extreme weather preventing them from participating in unsupervised, independent training at the Seniors Exercise Park. These barriers are consistent with the existing literature for Seniors Exercise Parks (Levinger, Dunn, et al., 2021; Sales et al., 2017) and findings of previous systemic reviews on physical activity participation in older adults (Franco et al., 2015; Spiteri et al., 2019). Different strategies can be used to address some of the factors influencing participants' adherence to unsupervised, independent practice. These strategies include:

- Install a shade cover over the exercise area compared to it being uncovered in the heat (Levinger, Dunn, et al., 2021; Levinger et al., 2018).

- Booster sessions to review participants' exercises and discuss their progress (Söderlund & von Heideken Wågert, 2021).
- Identify and train peers (i.e., participants within the program) as leaders (Khong et al., 2017; Thøgersen-Ntoumani et al., 2019) to lead the independent practice sessions (Ng, Hill, Levinger, et al., 2022).
- Providing more sessions across the week as options for them to use the equipment.

Another challenge was the interruption of data collection three times due to COVID-19 lockdown and restrictions. Although data collection was interrupted, it did not prevent access to the Seniors Exercise Park, as was reported to occur in another Seniors Exercise Park study conducted during the pandemic in Melbourne, where there were severe lockdowns relative to Perth (Levinger et al., 2020). All data in the feasibility study in this thesis were included and analysed, unlike the data from another Seniors Exercise Park study published in 2020, which excluded 20% (n = 19) of their participants for their nine month follow-up component due to data collection being impacted by COVID-19 (Levinger et al., 2020).

In summary, the Seniors Exercise Park program was feasible, safe, and improved health outcomes for older adults with mild balance dysfunction. In addition, the participants perceived the program as beneficial, regardless of their health conditions. Participants enjoyed the social connections associated with the program and felt supported by the instructor. Older adults with mild balance dysfunction need positive exercise facilitators (e.g., social connectedness) to overcome barriers to exercise. Challenges to Seniors Exercise Park interventions include managing dropouts and adherence to unsupervised independent practice, and strategies are needed to address these challenges. Findings support increased use of Seniors Exercise Parks for older adults with mild balance dysfunction.

The studies in this thesis were conducted during the COVID-19 pandemic, and the final study (Chapter 8) explored the impact of COVID-19 on physical activity participation among older adults living in retirement villages. This study (Ng, Hill, & Burton, 2022) found that:

- Older adults living in a retirement village continued their physical activity participation during the pandemic. However, the type of activity was limited, and the intensity of activity was also reduced. These findings are consistent with another study on physical activity of community-dwelling older adults with chronic health conditions (e.g., hypertension) during the pandemic (Kim et al., 2021).
- The most common activity that older adults engaged in during the pandemic was walking, which is supported by other studies (Greenwood-Hickman et al., 2021; Kim et al., 2021). However, Greenwood-Hickman et al. (2021) also reported that a small number of participants engaged in virtual exercise classes during the pandemic. This differs from the findings reported in the study in this thesis or other studies exploring physical activity participation by older adults during the pandemic (Goethals et al., 2020; Kim et al., 2021). Possible explanations might be that participants were unaware or lacked interest in virtual exercise programs or were inexperienced and unsure how to access these programs or did not have a computer/tablet (Cohen-Mansfield et al., 2021).
- Most participants perceived their mental well-being and social connectedness (i.e., face-to-face contact with friends and family) to be negatively affected during the pandemic, which is consistent with the results from Greenwood-Hickman et al. (2021) and Brown et al. (2021) in community-dwelling older adults. Older adults coped well by engaging in walking and leisure activities (e.g., gardening), maintaining social connections by using virtual communication (e.g., Skype) and/or

phone to communicate with their family and friends, and engaged in face-to-face interactions in the outdoor environment while following physical distancing rules, such as having a conversation with their neighbours while seated in their driveways drinking a cup of coffee. Other studies also reported that some older adults coped well by undertaking outdoor walking or other activities such as pursuing leisure activities (Greenwood-Hickman et al., 2021) and used various communication methods (e.g., phone, virtual communication) (Gonçalves et al., 2021; Greenwood-Hickman et al., 2021) during the pandemic.

In summary, older adults in this study perceived that the COVID-19 pandemic impacted their physical activity participation and daily life. However, a number of these older adults were resourceful and resilient by engaging in indoor physical and leisure activities, as well as outdoor activities where possible. They also adopted various modes of communication (e.g., virtual) to maintain social connections to help them cope with the pandemic.

9.2 Clinical implications

The information provided in the systematic review could be used for future research or policy on outdoor exercise parks in older adults that focus on developing and evaluating standardised parameters (e.g., frequency, intensity, duration) of outdoor exercise park interventions and their outcomes for older adults. This will enable effective comparisons between studies and assist in demonstrating the impacts and benefits of outdoor exercise park use for older adults. Balance training can reduce the rate of falls in older adults (Sherrington, Fairhall, Wallbank, et al., 2020; Sherrington et al., 2017), and the lack of balance training equipment installed in many outdoor exercise parks suggests that local authorities or councils should consider the inclusion of balance training equipment when designing their urban spaces and parks for older adults.

The modified version of the CBMS (CBMS-Home) is a reliable and valid scale for independent, community ambulant older adults and can be implemented in a wider range of settings, including those with limited space (e.g., home) and no stairs. The lack of ceiling effect for both the CBMS (Balasubramanian, 2015; Weber et al., 2018) and the CBMS-Home (Ng, Hill, Jacques, et al., 2021) is an important finding ensuring that these tools are suitable for identifying early or small/mild changes in balance and mobility decline. Older adults are prone to experience balance and mobility decline (Cruz-Jimenez, 2017). Balance and mobility decline is a problem that is responsive to intervention (Jadczak et al., 2018; Thomas et al., 2019), therefore, validating the CBMS-Home can provide an additional assessment tool for physiotherapists to identify and evaluate early balance changes in independent, community ambulant older adults in a timely manner for early prevention of falls, without the concern of encountering ceiling effects in its measurement.

The Seniors Exercise Park program reported in this thesis is the first study evaluating the feasibility (including safety and effects) of this approach in people with mild balance dysfunction. Importantly, the Seniors Exercise Park program provided new information on exercise interventions for older adults with mild balance dysfunction and reinforced the hypothesis that they can improve outcomes across multiple domains with a Seniors Exercise Park program. This study also demonstrated that sustained health professional supervision is not required for gaining health benefits, even for older adults with mild balance dysfunction – that after initial training and supervision, supervision can be gradually reduced to the point of safe, independent practice. These results also add to the growing body of evidence of multi-domain benefits of Seniors Exercise Park participation by older adults, including those with mild balance dysfunction, and highlights the need for more local councils to consider installing and supporting the use of Seniors Exercise Parks by older adults in their local government areas.

The findings of the impact of COVID-19 on physical activity in older adults have important implications for retirement villages and leisure and fitness centres. Providing training and resources for multi-modal activities able to be performed at home could provide older adults with an opportunity to remain healthy and fit while staying at home (Hammami et al., 2020; Said et al., 2020). It is recommended that health professionals and activity coordinators working with residents in retirement villages have access to reliable online, mobile applications and hard copy resources to support older adults' multi-modal activities at home should another pandemic arise. The continuation of services to help older adults maintain their physical activity is important. Leisure and fitness centres that previously provided services to older adults through physical locations (e.g., aerobic exercise classes, gym exercise classes) before the pandemic may consider providing the services online. This may assist older adults to continue enjoying the social interactions and connections, and health benefits gained during workouts at these physical locations, if they are forced to isolate. Mental well-being was perceived to be affected by older adults. Therefore, it is suggested that retirement village staff may want to co-develop coping strategy resources to support residents in facing the challenges of a pandemic affecting their mental well-being.

In summary, the main implications from these studies are that physiotherapists and other exercise practitioners should consider using CBMS-Home to identify early balance and mobility changes in the community where assessments are being conducted in home settings or settings with limited space / stairs. Seniors Exercise Park programs are a safe exercise option to improve health outcomes for older adults with mild balance dysfunction, and more local governments should consider installing

Seniors Exercise Parks in their community parks and urban spaces to increase access to these facilities. Finally, it is important to develop multi-modal physical activity resources (e.g., resources in hard copy, online, and mobile applications) to support older adults in future pandemics or incidents of a similar nature where group physical activity options are not available.

9.3 Strengths

The are several strengths presented in this thesis. The CBMS was limited in its' practical use in the community because it required a large space and stairs. The CBMS-Home, modified in this study; was valid and reliable in evaluating balance and mobility performance in independent, community ambulant older adults. This modification is an important step towards improving the feasibility of this tool for this population because the CBMS-Home can be implemented in settings with limited space (e.g., home) and no stairs, and offers an additional assessment tool to evaluate balance and mobility performance in high functioning older adults, without the concern of ceiling effects.

The Seniors Exercise Park studies had several strengths. This research extends current findings on Seniors Exercise Park use by older adults because it demonstrates for the first time the feasibility (including safety and health benefits) of this novel approach in an important sub-group of older adults; older people with mild balance dysfunction. In addition, this research provides a basis for exploring less resource-intensive approaches to Seniors Exercise Park use with fewer requirements for health professional supervision than previous studies of Seniors Exercise Parks (Levinger et al., 2020; Sales et al., 2017). There was a high representation of older women with mild balance dysfunction recruited from the retirement village in this study, which suggest the acceptability of the Seniors Exercise Park program in this population. Furthermore, the use of the mixed methods approach utilising quantitative and qualitative findings further strengthens the positive outcomes associated with Seniors Exercise Park use by older adults, by providing a comprehensive understanding of the feasibility (including safety and health benefits) of the Seniors Exercise Park program and factors influencing adherence to supervised training and independent practice in older adults with mild balance dysfunction. Moreover, this research utilised a modified tool (i.e., CBMS-Home) that underwent rigorous validation of its' measurement properties, which has application in home assessment settings for populations with mild balance dysfunction (given the lack of ceiling effects demonstrated).

The qualitative research on the physical activity of older adults during the COVID-19 pandemic is the first study to provide an in-depth insight into the impact of COVID-19 on the physical activity experiences of older adults living in retirement villages. The results can be used to generate practical recommendations for the promotion of physical activity in older adults living in retirement villages in future pandemics.

9.4 Limitations

The studies in this thesis met the objectives; however, there were several limitations, and these are described below:

- Even though the CBMS-Home can evaluate early balance changes in independent, community ambulant older adults without the concern of encountering ceiling effects in its measurement, its' clinical application is somewhat limited until cut-off points are developed to identify balance dysfunction (i.e., mild, moderate, or severe). Therefore, future research is needed to identify these cut-off points for older adults to receive early intervention.
- Although the results of the study demonstrated evidence regarding the efficacy of the Seniors Exercise Park program for older adults with mild balance dysfunction,

this study used a quasi-experimental pre-post study design that did not include a control group. It will be useful for the findings from this feasibility study to be replicated using a randomised control trial design for older adults with mild balance dysfunction and other clinical groups (for example, older adults who have had a stroke). In addition, the length of the program was 24 weeks and could be considered relatively short. Therefore, to determine long-term adherence to physical activity among older adults with mild balance dysfunction, the effects over a longer period should be investigated.

- Lockdowns occurred three times, and mask wearing was mandatory for five weeks of the Seniors Exercise Park program due to the COVID-19 pandemic. These lockdowns and mask wearing periods might have affected the physical and psychosocial health of the participants, which were not evaluated in this study. Therefore, future Seniors Exercise Park studies might want to consider evaluating the effects of a pandemic on the participants' physical and psychosocial health if one occurs in the future.
- Another limitation was the reporting of Seniors Exercise Park usage using diaries during independent practice. This reporting relied on the accurate and diligent documentation by participants. Previous studies monitored participants’ usage of a Seniors Exercise Park using an identification key (i.e., fob) where participants were able to tap on a fob reader each time they visited the Seniors Exercise Park (Levinger, Dunn, et al., 2021; Levinger et al., 2020). Although using the fob provided accurate information about the date, time of visit, and duration of exercise at the Seniors Exercise Park, it does not allow for additional exercises adapted from the Seniors Exercise Park to another environment to be recorded. These, however, were included in the diaries returned by the participants in this study and showed

how they were adapted to other environments by some of the participants. Although these exercises outside the Seniors Exercise Park were not included in the calculation of adherence to unsupervised independent practice, this information provided evidence that participants were doing additional activities to maintain their physical performance. Therefore, incorporating more than one strategy, such as a fob, written, online, phone interview, or mobile phone applications, could potentially improve the accuracy and richness of data collected about park usage and the exercises included in an intervention.

- A limitation (and opportunity) of the positive findings of the Seniors Exercise Park study in this thesis, and others conducted to date, is the lack of widespread availability of Seniors Exercise Parks across Australia and internationally. In comparison to many of the outdoor exercise equipment more widely available in community parks, this specialised equipment has the additional benefit of including exercise stations that challenge balance and focus on potential functional impairments in older adults. So, despite the growing evidence of health benefits, there is currently limited opportunity to implement this novel approach at a community or population level in Australia. It is hoped that further research and dissemination will support a greater availability of these specialised parks across all communities.
- The participants were purposively selected for the phone interview in the study on the experiences of COVID-19 on physical activity in older adults living in a retirement village, and there may be a risk of selection bias. In addition, the participants met the researcher in the previous validation study of CBMS-Home. This could have potentially led to more positive responses from the participants during the interview. Alternatively, this could have put the participants at ease

during the interview and meant they provided richer data. To ensure that the previous contact with the participants did not influence the interpretation of the data, all the interview data collected were analysed and coded by a second researcher independently. In addition, discussions were held with a third researcher to confirm the findings.

- A final limitation of the thesis relates to the low representation of men recruited in the CBMS-Home, Seniors Exercise Park, and experiences of COVID-19 in older adults' studies; therefore, generalising these results to men is limited. Although the studies tried to recruit men, as well as women, this had a low level of success. However, given the similar patterns of gender representation in previous studies of CBMS (Takacs et al., 2014; Weber et al., 2018), outdoor exercise parks (Chow et al., 2021; Kim et al., 2018; Levinger, Dunn, et al., 2021; Levinger et al., 2020; Liu et al., 2020; Sales et al., 2018; Sales et al., 2017), and experiences of older adults during COVID-19 (Greenwood-Hickman et al., 2021; Kim et al., 2021), the results suggest confidence regarding the robustness of the studies, despite this limitation.

9.5 Future research

The recommendations for future research were described in each chapter. This chapter includes additional recommendations that were not described earlier due to the word limits and submission requirements of the journals.

One of the focus of this PhD determined the reliability and validity of CBMS-Home among older adults living independently in the community (Ng, Hill, Jacques, et al., 2021). The CBMS has been validated amongst older adults with knee osteoarthritis (Takacs et al., 2014), those undergoing cardiac rehabilitation (Martelli et al., 2018), and following a stroke (Knorr et al., 2010), and appears useful to evaluate performance in older adults with balance and mobility problems in other populations (e.g., stroke)

(Chan et al., 2017). Therefore, further studies are needed to evaluate the measurement properties and use of CBMS-Home in other populations of older adults to expand the usage of the test.

A quasi-experimental pre-post study design was used for the Seniors Exercise Park study (Ng, Hill, Levinger, et al., 2022). With adequate resources and funding, there is a need for further, long-term RCTs to quantify the effectiveness of Seniors Exercise Park use among older adults with mild balance dysfunction. A RCT should include an adequately powered sample size and a wider sample of older adults with mild balance dysfunction recruited from across the community and potentially different jurisdictions. Also, qualitative interviews and outcome assessments undertaken as part of future studies should ideally be conducted by a researcher not directly involved in delivering the intervention.

The Seniors Exercise Park is a relatively new approach available to support older adults' physical activity participation. The small number of studies reporting Seniors Exercise Park interventions have used different parameters of implementation (i.e., number of sessions, frequency, duration, level of supervision, support for transition to independent use). While the Seniors Exercise Park study in this thesis has provided some useful additional information, it is also important to clarify whether there is an optimal dose (number of sessions, frequency, level of supervision, intensity, duration, load and support for transition to independent use) of exercise at the Seniors Exercise Park to optimise gains in physical performance and health benefits among older adults, including those with mild balance dysfunction in the shorter and longer term, and to determine whether Seniors Exercise Parks can prevent or reduce falls for older adults with mild balance dysfunction.

The Seniors Exercise Park has now been evaluated in research primarily with generally well older people, and older adults with mild balance dysfunction in the studies in this thesis. It still remains unknown whether this approach can be safely implemented, and also achieve positive benefits, for older adults with more advanced balance and mobility dysfunction. Further research is required with older adults with greater levels of balance and mobility impairment. In addition, the CBMS-Home data in this study can be used to provide pilot data for sample size calculations for researchers who wish to use the CBMS-Home in similar samples of older adults in future studies.

There was a high representation of women in the CBMS-Home, Seniors Exercise Park, and experiences of COVID-19 on older adults' physical activity studies. Further studies should aim to recruit more men. Several strategies suggested by a systematic review (Bracken et al., 2019) to enhance the recruitment of men included (i) working with health service providers to recruit men to the program; (ii) sending letters and study information to invite members from mailing lists obtained from various sources such as men's social clubs, volunteer database, and Department of Veterans' Affairs database; and (iii) using media coverage, such as advertising on radio, television, newspapers, social media and newsletters in men's social and activity clubs and medical institutions.

Physically active older adults from the retirement villages were interviewed during the height of the pandemic. Further qualitative studies are required to explore the physical activity experiences of older adults living in the community and including other populations (e.g., frail older adults) because they may have different physical activity experiences during COVID-19 or future pandemics compared to those residing in retirement villages and may require different support to assist them. In addition, further research needs to determine how to support older adults to engage in multi-modal physical activity at home effectively and to ensure that the activities they perform are of an adequate intensity. Future studies might consider exploring how and what type of communication technology can best support older adults to maintain social connections among their family and friends.

9.6 Conclusion

The series of studies in this thesis aimed to strengthen the evidence base, assist researchers and potentially clinicians who work with older adults by modifying an assessment tool (i.e., CBMS) to improve its utility in settings with limited space and lack of stairs, and to evaluate the Seniors Exercise Park in an important (because of their risk of progressive balance decline and falls), and previously unresearched population; older adults with mild balance dysfunction. Although the systematic review and meta-analyses results did not demonstrate any significant effects on lower body strength and balance, individual studies of outdoor exercise parks and this Seniors Exercise Park study showed improvements on multiple health outcomes (including lower body strength and balance) in independent community-dwelling older adults and those with mild balance dysfunction. In addition, the participants perceived the Seniors Exercise Park program favourably. The emergence of the pandemic provided an opportunity to explore how government restrictions (i.e., isolation and lockdowns) have impacted older adults' physical activity participation. The results showed that older adults in the retirement village continued being physically active during the pandemic, although the variety and intensity of activity were reduced. Collectively, the information from this thesis may aid the development of future resources and public health interventions to support older adults' physical activity engagement to promote better health generally, as well as during the occurrence of future pandemics or events of a similar nature.

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Appendices

Appendix 1 : Participant information sheet - Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment (Chapter 5)

Curtin University

PARTICIPANT INFORMATION STATEMENT

HREC Project Number:	HRE2019-0735
Project Title:	Evaluation of a modified version of the Community Balance and Mobility Scale (CBMS) for use in home assessment
Principal Investigator:	Dr. Elissa Burton, Senior Research Fellow, School of Physiotherapy and Exercise Science, Curtin University
Student researcher:	Michelle Ng Yoke Leng
Version Number:	2
Version Date:	16/10/2019

You are invited to participate in this study.

What is the Project About?

The research study is on an assessment used to evaluate balance and mobility in older people. Common balance and mobility tests are unable to detect early balance problems in older people. The Community Balance and Mobility Scale (CBMS) was found to be a valid and reliable test to assess balance and mobility problems amongst community-living older people. CBMS was also used in older people with osteoarthritis, stroke and low bone mass. However, it may not be possible to complete every task included in the current CMBS at someone's home (e.g. climbing at least 8 steps on a flight of stairs or using a 10 meter walkway). Therefore, this study is being conducted to evaluate whether item(s) on the CBMS can be removed or modified to allow assessments to be undertaken in the home. The functional reach test and step test are valid and reliable tests used to assess balance amongst older people. Both tests will be used to determine how well the modified version of the CBMS performs. The aim of this study is to evaluate a modified version of the Community Balance and Mobility Scale (CBMS) that is feasible for use within the home to assess older people's mobility and balance.

This study aims to recruit 50 participants living in the community.

Who is doing the Research?

The project is being conducted by Michelle Ng, who is a physiotherapist from Singapore and will be supervised by Dr. Elissa Burton (an experienced Exercise Scientist) from Curtin University and Professor Keith Hill (an experienced Physiotherapist) from Monash University. The results of this research project will be used by Michelle Ng to obtain a Doctor of Philosophy at Curtin University. The research project is funded by Curtin University and Michelle's studies are sponsored by the Singapore Institute of Technology. There will be no costs to you and you will not be paid for participating in this project. You will be reimbursed for parking fees if you come to Curtin University for assessments (if required).

Why am I being asked to take part and what will I have to do?

We are looking for volunteers (aged 65 years and above) who are walking independently with or without a walking aid. If you agree to participate in this research project, you will be asked to go through the same assessment as all other participants. The assessment will be repeated on **two different days** as listed under the "Schedule of visits". Each assessment session will take approximately 45 to 60 minutes.

During the first assessment, we will ask you questions about you (e.g. age, education), your current health and past medical conditions. We will then ask you to complete the balance and mobility walking assessments which will include tasks such as standing on one leg and stepping up and down a step. It would be beneficial to wear comfortable flat shoes while completing the tasks and you will wear a safety waist belt so that the researcher can help you (if you are not steady) while performing the tasks. You might experience some tiredness during certain task(s), which is expected and normal. You will be provided with rest breaks whenever required or at the end of every task. Do be assured we will take precautions and ensure your comfort and safety at all times during the test. If you are unable to complete any test(s), or have any concerns during the session, please let us know immediately. We will assess and take necessary actions to ensure your comfort and safety.

During the second assessment, you will be asked to repeat the same balance and mobility walking assessments under the same conditions as the previous occasion (i.e. use safety belt, plenty of rest). It would be beneficial to wear the same comfortable flat shoes again while completing the tasks.

The study will take place at Curtin University and/or your home or a preferred place in the community which must have a flight of stairs (minimum of 8 steps).

Schedule of visits and procedures

Visit 1: Undergo up to 60 minutes of assessments, which includes questions about you (e.g. age, education), and the balance and mobility tests.

Visit 2: Five to 10 days after Visit 1. Undergo up to 45 minutes of assessment which includes the balance and mobility tests.

Optional Consent: Future Research: We would like you to consider allowing us to send you information about future research projects. If you do agree, please note that when you receive the information you can still decide then whether you would like to take part or not.

Are there any benefits' to being in the research project?

There may be no direct benefit to you from participating in this research. We hope the results of this research will allow us to determine whether the modified set of tasks and the removal of one/some of the task(s) will affect validity (i.e. how well a test measures what it is supposed to measure) of the CBMS. The results of the research will enable us to have a practical tool which can be easily administered in the community (in people's homes) that can accurately detect small changes in balance and mobility among older people.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

Apart from giving up your time, there are no foreseeable risks from this research project. The assessment procedures are unlikely to have any side effects. As with any form of physical activity, there are small but possible risks associated with participation. These risks include fatigue, pain or injury. Rest breaks will be provided throughout testing and you will wear a safety waist belt during the balance and mobility assessments to minimise these risks. The tests do not involve any invasive procedures.

Who will have access to my information?

The information collected in this research will be de-identified (coded). We will remove identifying information on any data and replace it with a code. Only the research team have access to the code to match your name if it is necessary to do so. Any information we collect will be treated as confidential and used only in this project unless otherwise specified.

The following people will have access to the information collected in this research: the research team and the Curtin University Human Research Ethics Committee. Electronic data will be password-protected and hard copy data will be stored in a locked cupboard at Curtin University.
The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed. You have the right to access, and request correction of, your information in accordance with relevant privacy laws. The results of this research may be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?
If you would like a summary of the results, please let Michelle know during the first assessment. The full results will be available if it is accepted for publication in a peer-reviewed journal or in Michelle Ng's dissertation.

Do I have to take part in the research project?
Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. Please let us know you want to stop so we can make sure you are aware of anything that needs to be done so you can withdraw safely. If you choose not to take part, or start and then stop the study, it will not affect your relationship with the University, staff or colleagues. If you choose to leave the study we will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?
If you have any questions about this research study, please contact:

Ms. Michelle Ng, Ph.D. Student, Curtin University
Contact number: (08) 92664926, E-mail address: yokeleng.ng1@postgrad.curtin.edu.au
OR
Dr. Elissa Burton, Exercise Scientist, Curtin University
Contact number: (08) 92664926, E-mail address: E.Burton@curtin.edu.au

If you would like to take part in this research study we will ask you to kindly sign the consent form. By signing it is telling us that you understand what you have read and what has been discussed. Signing the consent indicates that you agree to be in the research project and have your information be used as described above. Please take your time and ask any questions you have before you decide. You will be given a copy of this information sheet and the consent form to keep.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2019-0735). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 2 : Participant information sheet - Seniors Exercise Park program for older adults with mild balance dysfunction – A feasibility study (Chapters 6 and 7)

PROUDLY SUPPORTED BY

Curtin University

Town of Victoria Park

PARTICIPANT INFORMATION STATEMENT

HREC Project Number:	**HRE2019-0734**
Project Title:	Seniors Exercise Park (SEP) programme for older people with and without mild balance dysfunction.
Principal Investigator:	Dr. Elissa Burton, Senior Research Fellow, School of Physiotherapy and Exercise Science, Curtin University
Student researcher:	Michelle Ng
Version Number:	4
Version Date:	05/11/2020

You are invited to participate in this study.

What is the project about?

This is a study to improve physical function (i.e. balance, strength and physical activity levels) and psychosocial outcomes such as well-being for older people through an exercise programme conducted in an outdoors Seniors Exercise Park (SEP). Improving mobility, balance and strength has helped older people improve their function, well-being and reduced their risk of falling.

This study targets older people who are generally well, those with mild balance problems or mild unsteadiness, and those who have concerns about their balance and may feel unsteady during certain activities such as turning. Older people need to practice activities that are most similar to the activity that they want to improve in. This is known as specificity of training. Therefore, the exercise program at the Seniors Exercise Park will include a combination of balance, strength and fitness exercises. SEP are outdoor exercise parks that consist of a "kit" of fitness equipment built specifically for older people. They consist of a variety of exercise stations with a range of functional activities built to improve strength, flexibility, mobility and balance. It is **unique and different** compared to normal outdoor gyms in parks because it includes exercise equipment to train **balance**.

Who is doing the research?

The project is being conducted by Michelle Ng, who is a physiotherapist from Singapore and will be supervised by Dr. Elissa Burton (an experienced Exercise Scientist) from Curtin University and Professor Keith Hill (an experienced Physiotherapist) from Monash University.

Why am I being asked to take part and what will I have to do?

You have been invited to take part because as a person ages it is important to be physically active and in particular to continue improving strength and balance. Improving strength, balance and mobility is important to help you to live independently and to reduce the risk of falling. This research project would require you to participate in a fun and novel exercise program twice a week. You will be exercising using outdoor exercise park equipment for an hour each time. If you are keen to participate, Michelle will ask you a few questions to determine whether you are suitable for exercise. If you are eligible to participate and have had all of your questions answered we will need your written consent that you are happy to participate and understand the study prior to starting. Once consent is received, Michelle will ask you some questions about yourself, complete some questionnaires and conduct

some baseline tests on your physical function such as standing up from a chair. Michelle will meet you on a one to one session at the exercise park to show you how to use the equipment and determine the most appropriate starting level for you. The exercise programme will be conducted in a group and run for 18-weeks by Michelle. At the end of 18 weeks, Michelle will ask you to complete the same questionnaires and ask you to complete the physical function tests again to see if there are any changes in your physical health and well-being. You may also be interviewed to find out about your experiences in the programme. The interview will be audio recorded to allow Michelle to capture all the information discussed during the interview.
After the 18 weeks you are asked to continue the exercises at the exercise park independently for the next six weeks. Michelle will inform you about occasional times she is at the SEP to help you with any difficulties or issues exercising on your own. Each time you use the exercise park we would like you to record this in a diary we will give you. At the end of the month we will ask you to return it to us using a reply paid envelope or you can pass it to the Michelle directly. At the end of the six weeks of unsupervised park use, Michelle will ask you to complete the same questionnaires and get you to complete the physical function tests again to see if there are any changes at the end of the programme. You may also be interviewed to find out your experiences about exercising on your own and factors that encouraged you to continue exercising. Similarly, the interview will be audio recorded to allow Michelle to capture all the information discussed during the interview.
During the assessment and intervention, if you are uncomfortable with any study procedure, you have the right to decline that procedure or withdraw from the research for any reason including any coronavirus-related reason.

Assessment sessions will take place at Curtin University, your home or a venue in the community where you feel comfortable.
Exercise sessions will take place at SEP at the following locations:
1. SwanCare Bentley Park, 26 Plantation Drive, Bentley, WA 6102
OR
2. Neil McDougall Park, 18 Ley St, Como WA 6152
OR
3. Read Park, 5 Salford St, Victoria Park, WA 6100
Optional Consent: Photos and/or Video release: We would like you to consider allowing us to take photos and/or videos during the research project. The purpose of this is to increase interest and illustrate the research results. If you do agree, please tick the box on the consent form. Please note if you would like we can also cover your face in the photos, just let us know if this is what you prefer. If you do not want your photo taken please do not tick that box on the consent form.

Are there any benefits to being in the research project?
Older people who exercise have been shown to have improved balance, strength, mobility, well-being and reduced number of falls compared to those who are not physically active. By participating in this programme, you may achieve similar gains. We hope that this research will provide evidence that this programme conducted in an outdoor exercise park can be delivered safely for older people with and without mild balance problems and provide an alternative, fun, physical activity option for older people.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?
There is a small risk that you may fall during the exercise programme. However, the likelihood of this will be kept to a minimum by ensuring the programme you undertake is tailored to your abilities, ensuring additional safety factors such as non-slip surfaces on the exercise equipment, avoiding

exercise during extreme weather conditions, and provision of water for hydration. You may also feel some muscle soreness and stiffness when commencing the programme, or if resuming after a break from exercise. Generally, this resolves quickly, but if it persists, please contact Michelle, who will review and modify your programme of exercises. The research team are trained to deliver this type of exercise programme and will deal with any incident in an appropriate way. If you do not want to answer a question in the interview or in the unlikely event a question causes you distress, please tell us you do not want to answer that question. There is a small risk that you may contract coronavirus. The likelihood of this will be minimised by practicing physical distancing, sanitising your hands prior to using the shared exercise equipment and before leaving the exercise park, cleaning of shared equipment between sessions, and disinfecting equipment prior to use. There will be no costs to you and you will not be paid for participating in this project. You will be reimbursed for parking fees if you come to Curtin University for assessments (if required).

Who will have access to my information?

The information collected in this research will be de-identified (coded). We will remove identifying information on any data and replace it with a code. Only the research team have access to the code to match your name if it is necessary to do so. Any information we collect will be treated as confidential and used only in this project unless otherwise specified. The research team and the Curtin University Human Research Ethics Committee will have access to the information collected in this research. Electronic data will be password-protected and hard copy data will be stored in a locked cupboard at Curtin University.

The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed. You have the right to access, and request correction of, your information in accordance with relevant privacy laws. The results of this research may be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?

If you would like a summary of the results, please let Michelle know. We will e-mail you at the end of the project and let you know the results. Results will not be individual but based on all the information we collect and review as part of the research. We hope to publish the results in a peer review journal article with a focus on older people. The results of this research project will be used by Michelle Ng to obtain a Doctor of Philosophy at Curtin University and is funded by Curtin University.

Do I have to take part in the research project?

Taking part in this research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. Please let us know you want to stop so we can make sure you are aware of anything that needs to be done so you can withdraw safely. If you choose not to take part, or start and then stop the study, it will not affect your relationship with the University, staff or colleagues. If you choose to leave the study we will use any information collected unless you tell us not to. If you stop participation at any time, you will be asked to complete an exit survey, to provide information on factors contributing to cessation of participation.

What happens next and who can I contact about the research?

If you are interested in participating in this study or have any questions, please contact:
Ms. Michelle Ng, Ph.D. Student, Curtin University

Contact number: (08) 92664926, E-mail address: yokeleng.ng1@postgrad.curtin.edu.au
OR
Dr. Elissa Burton, Exercise Scientist, Curtin University
Contact number: (08) 92664926, E-mail address: E.Burton@curtin.edu.au

If you would like to take part in this research study we will ask you to kindly sign the consent form. By signing it, you are telling us that you understand what you have read and what has been discussed. Signing the consent indicates that you agree to be in the research project and have your information be used as described above. Please take your time and ask any questions you have before you decide. You will be given a copy of this information sheet and the consent form to keep.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2019-0734). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 3 : Seniors Exercise Park participant orientation handout

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Participant orientation session briefing at the exercise park (30 to 45 minutes)

Welcome to the Seniors Exercise Park programme.

Becoming physically active is important because regular exercise can help you continue doing the things you like doing and remain independent. Do not worry if you stopped doing exercise for some reason or if you have never exercised before.

The Seniors Exercise Park programme is to help you get moving and to have some fun with others.

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The Seniors Exercise Park is a novel approach to improve strength, flexibility, mobility and balance using a variety of outdoor exercise stations with a range of functional activities. It is **unique and different** compared to normal outdoor gyms in parks because it includes exercise equipment to improve **balance**.

Key points of the outdoor Seniors Exercise Park programme

- You will learn to use and practice the outdoor Seniors Exercise Park equipment to target and improve strength, flexibility, mobility, and balance.
- If you want to improve balance, you need to practice activities that challenge your balance.
- If you want to improve strength, you need to practice activities that make your muscles work harder.
- You will learn to incorporate the Seniors Exercise Park as part of your physical activity into your weekly routine independently.

Safety FIRST

- Always hold onto a sturdy and stable support or bar of the exercise equipment if you feel unsteady.
- Always listen to your body. Physical activities should not make you breathe so hard that you can't talk.
- If an illness stops you from coming to the exercise program, contact Michelle before starting again. You might need to resume exercising at a slightly lower level or with less amount of each exercise until your body gets back to its previous level of exercise.
- If are feeling sick, do **NOT** come for any exercise or assessment sessions. Seek medical advice.

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Exercising at the exercise park

- Wear flat, non-skid soles, good heel support shoes.[1]
- Wear lightweight, loose fitting clothing which helps sweat evaporate.[2]
- Hold onto a sturdy support or bar of the exercise equipment if you feel unsteady.
- Do not hold your breath during exercises.[2]
- Always apply sunscreen and wear sunglasses or a wide-brimmed hat or cap.
- Drink water before, during and after your exercise session.[1,2]
- If you are unsure about using any of the fitness equipment, inform Michelle.
- You will perform exercises in a group with similar balance function. You will be paired with another participant during exercise so that you could swap exercise stations after completing exercises at your own station.
- Please sanitise your hands prior to touching shared exercise park equipment and before you leave the exercise park.
- Please attempt to practice physical distancing whenever you are using the outdoor exercise park equipment.

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If you experience any of the following symptoms while exercising, inform Michelle immediately:

- Any new symptom you haven't discussed with Michelle previously.[1,2]
- Dizziness.[1,2]
- Shortness of breath (i.e. you are not able to speak because of shortness of breath).[1,2]
- Chest pressure or pain.[1,2]
- The feeling that your heart is racing or skipping.[1,2]
- Severe pain in your joints.[1,2]

Delayed muscle onset soreness

- You may feel some muscle soreness when you start your exercises. This is good because it means you are working your muscles, it should however go away in a few days and lessen as you get used to doing the exercises.

Weather

- Classes will be canceled or postponed if there is a heavy downpour, lightning, or it is too hot.
- You may be affected by cold and heat more than others. If temperatures are too cold, it can lead to a large drop in body temperature. Dress in layers so you can remove clothes as required. In cold weather, you may want to wear gloves to avoid your hands becoming cold.[2]

Rate of Perceived Exertion (Category Ratio Scale)[3]

Instructions:
You will be asked to score the rate of perceived exertion you feel before, during and at the end of each physical activity session. This scoring will provide the researchers with information about how strenuous the exercise session feels to you. It should combine all feelings and sensations of effort, fatigue and physical stress of the exercise to you.

The rating "0" is nothing at all, 3 is moderate, 5 is hard and 10 is very, very hard, what is your score now?

Rating	Description	
0	Nothing at all	Activities such as sitting or lying, low energy needed.
0.5	Very, very, light	
1	Very light	No change in breathing rate and activity can be maintained for 60 minutes.
2	Fairly light	
3	Moderate	Able to maintain a conversation without interruptions.
4	Somewhat hard	
5	Hard	You are not able to maintain a conversation without interruptions.
6		
7	Very hard	
8		
9		
10	Very, very hard (Maximal)	An intensity that cannot be maintained longer than 10 minutes

References

1. Health Promotion Board. National physical activity guidelines: professional guide. Health Promotion Board. https://www.exerciseismedicine.org/singapore/assets/page_documents/NPAG_Professional_Guide.pdf. Accessed 19 August, 2019.
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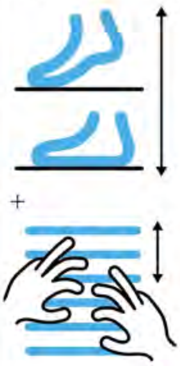
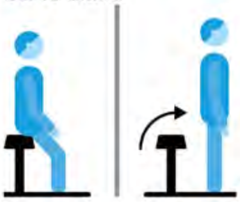
3. Borg AVG. Psychophysical bases of perceived exertion. *Medicine & Science in Sports & Exercise.* 1982;14(5):377-381.

Appendix 4 : Seniors Exercise Park exercises

No	Exercise[1]	Purpose
1.	Push-up bar 	Strengthens arms, legs and trunk.
2.	Pull – ups[2] 	Strengthens arms and trunk.
3	Calf raises 	Strengthens calves, improves shoulder flexibility and improves balance.
4.	Step-ups 	Strengthens lower leg muscles and improves balance
5.	Hip abduction 	Strengthens hip muscles and improves balance.

6.	Gangway 	Helps to improve balance.
7.	Balance stool 	Helps to improve balance.
8.	Balance Beam 	Helps to improve balance.
9.	Taps on Platform 	Helps to improve balance, coordination, and lower legs strength.
10.	Hip Extension 	Strengthens hip muscles and improves balance.
11.	Walking ramp and net 	Strengthens leg muscles, improves balance and coordination.

No	Exercise[1]	Purpose
12.	Snake Pipe – Small Wave 	Helps to maintain shoulder range of motion, hand eye coordination and improve balance.
13.	Snake Pipe – Big Wave 	Helps to maintain shoulder range of motion, hand eye coordination, trunk movement and improve balance.
14.	Hand roll 	Helps to maintain and improve mobility of shoulders and elbow joints.
15.	Core Twister 	Helps to improve back mobility and strength of trunk muscles.
16.	Shoulder Arches 	Helps to improve flexibility and mobility of the shoulder, elbows and chest.

No	Exercise[1]	What is the exercise for?
17.	Sit to stand 	Helps to improve strength of the lower legs and back.
18.	Stairs 	Helps to improve your fitness and strengthens your lower legs.

Graphic images (1,3 to 18) provided by the National Ageing Research Institute (ENJOY project https://www.nari.net.au/enjoy)

References

1. Sales MPR, 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;15:1-17.
2. Creative Stall. Pull Up. Noun Project.

Appendix 5 : Seniors Exercise Park independent practice handout

PROUDLY SUPPORTED BY

Curtin University

VICTORIA PARK

Exercising at the Seniors Exercise Park independently

Image removed due to copyright restrictions

Congratulations for completing the
18-week Seniors Exercise Park (SEP) programme!
You are on your way to continuing to incorporate these exercises as part of your lifestyle.
Doing exercise regularly is one of the best things you can do for your health and well-being. After starting your exercises at the Seniors Exercise Park, you may have noticed that you are feeling more energetic, getting stronger and can do things faster, easier or longer than before. Now is the time to build on those benefits by continuing the exercises on your own.

Why exercise at the Seniors Exercise Park?

The Australian Physical Activity guidelines recommend that you should accumulate 30 minutes of moderate intensity physical activity most days or every day, and it should include strength, fitness, balance and flexibility components.[1,2]

The Seniors Exercise Park consist of a variety of outdoor exercise stations with a range of functional activities built to improve strength, flexibility, mobility and balance. It is **unique and different** compared to normal outdoor gyms in parks because it includes exercise equipment to train **balance**. Therefore, you can get all the required health benefits by performing physical activity at a single location, i.e. at the Seniors Exercise Park.

Key points of continuing exercises on my own

- If you want to improve balance, you need to practice activities that challenge your balance.
- If you want to improve strength, you need to practice activities that make your muscles work harder.
- If you do not maintain your exercises, the health benefits gained during the last 18 weeks are often not maintained. Therefore, it is highly recommended that you continue your exercises.

Important tips to remember!

1. Your Safety is FIRST.

- Always hold onto a sturdy and stable support or bar of the exercise equipment if you feel unsteady.
- Always listen to your body. Physical activities should not make you breathe so hard that you can't talk.
- If are feeling sick, do NOT go to the exercise park to exercise. Seek medical advice.
- If an illness stops you from continuing the exercise program, contact Michelle before starting again.

- Dizziness.[3,4]
- Shortness of breath (i.e. you are not able to speak because of shortness of breath). [3,4]
- Chest pressure or pain. .[3,4]
- The feeling that your heart is racing or skipping. .[3,4]
- An infection or fever.[3,4]
- Joint swelling.[3,4]

3. How to reduce injury.

- It is not possible to predict when, where and how you might fall. Therefore, it is important to think ahead and make a plan of things you can do to safeguard yourself. You are advised to do the following:
    - Arrange with your friend or family member or neighbour to go with you to the exercise park initially when attending outside of the supervised group sessions.
    - Always carry your mobile phone in your pocket so that you can call for help if needed.
    - You might make an arrangement with a friend or family member or neighbour to contact you at a certain time to ensure that you are going ok.[5]

4. Always check the weather forecast.

- Check the weather forecast first. Cancel or postpone your exercise if there is a heavy downpour, lightning, or it is too hot.
- Consider doing exercises in the early morning or late afternoon.
- You may be affected by cold and heat more than others. [1] If temperatures are too cold, it can lead to dangerous drop in body temperature. Dress in layers so you can remove clothes as required.[1] If the weather is cold, you may want to wear gloves to avoid your hands becoming cold.[3]
- If temperatures are too hot, it can cause heat stroke.[1]Avoid exercising between 11am to 3pm during the summer, and ensure you have water to drink on hot days and wear a hat.

5. When exercising at the exercise park:

Image removed due to copyright restrictions

- Wear flat, non-skid soles, good heel support shoes. [3,4]
- Wear lightweight, loose fitting clothing which helps sweat evaporate.[4]
- Always warm up (do gentle exercises, see below) for at least 5 to 10 minutes at the beginning of each exercise session. [3,4]
- Always cool down (do gentle exercises, see below) at the end of each exercise session for at least 5 to 10 minutes to allow gradual decrease in breathing and heart rate to pre-exercise levels. [3,4]
- Hold onto a sturdy support or bar of the exercise equipment if you feel unsteady.
- Do not hold your breath during exercises.[3]
- Pay attention to your surroundings such as consider possible trip hazards, weather, uneven walking surfaces surrounding the exercise park.[5]
- Always apply sunscreen and wear sunglasses or a wide-brimmed hat or cap.
- Drink water before, during and after your exercise session. [3,4]

- Do not go to the exercise park immediately after it has rained because the fitness equipment will be wet and slippery.
- If you are unsure about using a particular piece of fitness equipment, stop using it. Please contact the researcher or meet her at the exercise park to clarify how to use the equipment.
- Please sanitise your hands prior to touching shared exercise park equipment and before you leave the exercise park.

Warm up and cool down exercises

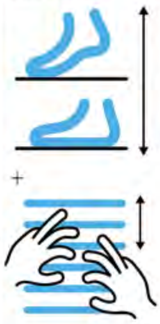
- **Always** warm up for at least 5 to 10 minutes at the beginning of each exercise session. [3,4]
- **Always** cool down after each exercise session for at least 5 to 10 minutes to allow a gradual decrease in breathing and heart rate to pre-exercise levels. [3,4]

No	Exercise	What is the exercise for?	Instructions
1.	Image removed due to copyright restrictions https://www.spotebi.com/exercise-guide	To gradually increase your heart rate and warm your muscles.	March on the spot or walk around the exercise park for ___ minutes. ☐ Holding onto stable support. ☐ No hand support.
2.	Image removed due to copyright restrictions https://www.spotebi.com/exercise-guide	To warm up shoulders, arms and shoulders.	Raise ☐one or ☐both arms to the sides. Rotate your arms forward making small circles for 30 seconds. Then rotate your arms backward making small circles for 30 seconds. ☐ Holding onto stable support. ☐ No hand support.
3.	Image removed due to copyright restrictions https://www.spotebi.com/exercise-guide	Maintain shoulder flexibility	Bring one arm across your body. Use the other arm to pull towards chest gently. Hold for 30 seconds. Change and stretch the other arm. Do 1 time. ☐ Seated on a chair. ☐ Standing with feet shoulder width apart.
4.	Image removed due to copyright restrictions https://www.spotebi.com/exercise-guide	To warm up the hip and lower back muscles.	Stand with your feet shoulder width apart. Slowly rotate your hips making circles in one direction for 30 seconds. Switch to the opposite direction. ☐ Holding onto stable support. ☐ No hand support.

No	Exercise	What is the exercise for?	Instructions
5.	Image removed due to copyright restrictions https://www.spotebi.com/exercise-guide	To warm up your leg, calf and ankle.	Stand with your feet shoulder width apart. Shift your weight to the left leg. Rotate your right foot by making small circles in one direction for 30 seconds. Switch to the opposite direction. Repeat with left foot. ☐ Holding onto stable support. ☐ No hand support.
6.	Image removed due to copyright restrictions https://www.spotebi.com/exercise-guide	Maintain calf and back thigh muscle flexibility.	Stand holding onto a stable support. Keep your right leg back with foot on the ground. Lean forward and slowly bend your left knee until you feel a stretch in your lower calf. Hold the stretch for 30 seconds. Repeat with other leg.

Exercising at the Seniors Exercise Park

- You are encouraged to build up to 30 minutes of exercising at the Seniors Exercise Park two to three times per week.
- To help you adhere to the program, record the days you complete the exercises. At the end of each month could you please return using the reply paid envelope provided.

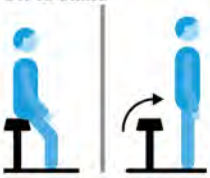
No	Exercise[6]	What is the exercise for?	Instructions	Specifications	Notes
1.	Push-up bar 	Strengthens arms, legs and trunk.	Push your body away from the bar and lower your body towards the bar.	☐ Wide grip ☐ Narrow grip	
2.	Pull – ups[7] 	Strengthens arms and trunk.	Stand with the feet positioned directly beneath the horizontal bar. Pull your body up towards the bar.	☐ Hands narrow, under grip ☐ Hands wide, under grip ☐ Hands narrow, over grip ☐ Hands wide, over grip ☐ Modified feet position (feet positioned forward).	
3	Calf raises 	Strengthens calves, improves shoulder flexibility and improves balance.	Stand on tiptoes. At the same time, climb and reach your fingers to the highest point.	☐ Stand facing the bar, tiptoe on both feet, climb with both hands. ☐ Stand facing the bar, tiptoe on one foot, climb with both hands. ☐ Stand with your side on the bar, tiptoe on both feet, climb with 1/both hands. ☐ Stand with your side on the bar, tiptoe on one foot, climb with 1/both hands.	

No	Exercise[6]	What is the exercise for?	Instructions	Specifications	Notes
4.	Step-ups 	Strengthens lower leg muscles and improves balance	Step up and down the platform.	☐ Alternating legs with hand support. ☐ Alternating legs with no hand support. ☐ 5 on each leg, with hand support. ☐ 5 on each leg, no hand support. ☐ 10 on each leg, with hand support. ☐ 10 on each leg, no hand support.	
5.	Hip abduction 	Strengthens hip muscles and improves balance.	Keep your knee straight and lift your leg sideways.	☐ Do 5 times. ☐ Do 10 times. ☐ Do 15 times. Hold ______seconds.	
6.	Gangway 	Helps to improve balance.	Ensure you place your foot firmly on the moving plank before shifting your next foot.	☐ Hold stable support with both hands. ☐ Hold stable support with one hand.	
7.	Balance stool 	Helps to improve balance.	Stand with foot shoulder width apart. Push down edges of the stool with alternate legs.	☐ Hold bar with 2 hands. ☐ Hold bar with 1 hand. ☐ No hand support. ☐ Lift hands overhead. ☐ Alternating hands overhead.	

No	Exercise[6]	What is the exercise for?	Instructions	Specifications	Notes
8.	Balance Beam 	Helps to improve balance.	Walk back and forth on the balance beam.	☐ Walk normally with hand holding onto support. ☐ Walk normally with no hand support. ☐ Walk heel to toe with hand holding onto support. ☐ Walk heel to toe with no hand support. ☐ Walk on toes with hand holding onto support. ☐ Walk on toes with no hand support.	
9.	Taps on Platform 	Helps to improve balance, coordination and lower legs strength.	Place your foot on the platform and return it back fully on the ground.	☐ Tap left foot on the platform, alternating legs with hand holding onto support. ☐ Tap your foot on the platform, alternating legs with arms on side of body. ☐ Tap your foot on the platform, alternating legs with hand holding onto support. ☐ Tap your foot on the platform, alternating legs with arms in front of body. ☐ Tap your foot on the platform, alternating legs with arms above the head.	
10.	Hip Extension 	Strengthens hip muscles and improves balance.	Keep your knee straight and lift your leg backwards.	☐ Do 5 times. ☐ Do 10 times. ☐ Do 15 times. Hold ______seconds.	

No	Exercise[6]	What is the exercise for?	Instructions	Specifications	Notes
11.	Walking ramp and net 	Strengthens leg muscles, improves balance and coordination.	☐ Walk normally to the ramp and step down through the net. ☐ Walk normally to the ramp and step onto the rope.	Walk to the ramp and step down **without touching the net:** ☐ Walk with narrow stance with 2 hands holding onto support. ☐ Walk with narrow stance with 1 hand holding onto support. ☐ Walk with narrow stance with no hand support. ☐ Walk with wide stance with 2 hands holding onto support. ☐ Walk with wide stance with 1 hand holding onto support. ☐ Walk with wide stance with no hand support. Walk to the ramp and step down **walk balancing on the ropes:** ☐ Walk with narrow stance with 2 hands holding onto support. ☐ Walk with narrow stance with 1 hand holding onto support. ☐ Walk with narrow stance with no hand support. ☐ Walk on **crosses** of the net with no hand support ☐ Walk with wide stance with 2 hands holding onto support. ☐ Walk with wide stance with 1 hand holding onto support. ☐ Walk with wide stance with no hand support.	

No	Exercise[6]	What is the exercise for?	Instructions	Specifications	Notes
12.	Snake Pipe – Small Wave 	Helps to maintain shoulder range of motion, hand eye coordination and improve balance.	Hold and move the ring from one end to the other end without touching the pipe.	☐ Facing sideways and walk normally looking forward. ☐ Facing sideways and walk using tandem walk (i.e. heel-toe). ☐ Facing sideways and walk on your heels. ☐ Facing sideways and walk on your toes.	
13.	Snake Pipe – Big Wave 	Helps to maintain shoulder range of motion, hand eye coordination, trunk movement and improve balance.	Hold and move the ring from one end to the other end without touching the pipe.	**Stand facing the snake pipe.** ☐ Place your feet shoulder width apart. Move the ring and change hands in the middle. ☐ Place your feet shoulder width apart. Move the ring across your body. ☐ Place your feet close together. Move the ring and change hands in the middle. ☐ Place your feet together. Move the ring across your body. **Stand with your side next to the snake pipe.** ☐ Place your feet shoulder width apart. Move the ring forward and backward. ☐ Place your feet close together. Move the ring forward and backward. ☐ Place one foot directly in front of the other foot. Move the	

				other foot. Move the ring forward and backward. ☐ Stand on one leg (outer most). Move the ring forward and backward. ☐ Stand on one leg (i.e. leg closest to snake pipe). Move the ring forward and backward.	
14.	Hand roll 	Helps to maintain and improve mobility of shoulders and elbow joints.	Grip the handles with both hands and turn the wheel in one direction. Rest whenever you need to.	Do _____ times.	
15.	Core Twister 	Helps to improve back mobility and strength of trunk muscles.	Stand on the platform with slightly bend knees. Hold onto the bar and twist your body from side to side. Start slowly and look straight ahead. Rest whenever you need to.	Do _____ times.	
16.	Shoulder Arches 	Helps to improve flexibility and mobility of the shoulder, elbows and chest.	Stand in the middle of the equipment. Hold the ball with one/both hands and move the ball along the bar. Rest whenever you need to.	Do _____ times.	
17.	Sit to stand 	Helps to improve strength of the lower legs and back.	Sit down and stand up from the seat or squat and touch the seat. Rest whenever you need to.	Do _____ times.	

No	Exercise[6]	What is the exercise for?	Instructions	Specifications	Notes
18.	Stairs 	Helps to improve your fitness and strengthens your lower legs.	Hold onto the rail. Climb up and down the stairs. Rest whenever you need to.	Do _____ times.	

Graphic images (1,3 to 18) provided by the National Ageing Research Institute (ENJOY project https://www.nari.net.au/enjoy)

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7. Creative Stall. Pull Up. In: Noun Project.

Appendix 6 : Screening - Standardised questionnaires

1. The Physical Activity Readiness Questionnaire (PAR-Q+)

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2. Abbreviated Mental Test Score

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Appendix 7: Efficacy testing - Standardised questionnaires

1. European Quality of Life Scale-5D-5L (EQ-5D-5L)

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2. Modified Falls Efficacy Scale

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3. Physical Activity Scale for the Elderly (PASE)

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4. UCLA Three-Item Loneliness Scale

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5. Self-Efficacy Scale for Exercise

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6. Five-Item World Health Organisation Well-Being Index (WHO-5)

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Appendix 8 : Seniors Exercise Park participant exercise diary

Seniors Exercise Park Diary Curtin University

INSTRUCTIONS

1. You are required to complete the diary every time you visit and perform exercises at the Seniors Exercise Park.
2. Always do warm up and cool down exercises for at least 5 to 10 minutes at the beginning and end of each exercise session.
3. You are encouraged to spend at least 30 minutes performing physical activity using the exercise park equipment.
4. If you are unsure about how to perform any of the exercises, do not continue. Please contact Michelle.
5. Always listen to your body. Physical activities should not make you breathe so hard that you cannot talk.
6. Please complete the following details at the respective rows: Date , repetitions and or sets of exercise, any difficulties performing exercises, total duration spent at the exercise park
7. "X" signifies the number of times/repetitions of exercise
8. Rate of perceived exertion is a score of how strenuous you feel during the exercise. The rate of "0" is nothing at all and "10" is very, very hard.

Here is a sample of how the diary is completed:

Type of Exercise	Date of visit to the Seniors Exercise Park					
	20-08-19	23-08-19				
Time of Exercise	8.30am to 8.50am	9.00am to 9.15am				
Push up bar	12 X	12 X				
Pull ups	12X	12X				
Calf raises & finger	12 X 2 sets	12 X 2 sets				
Step-ups	12 X	12 X				
Hip Abduction	12 X	12 X				
Gangway	12 X	12 X				
Balance stool	12 X 3 sets	12 X				
Total duration spent at the exercise park	20 minutes	15 minutes				
Rate of perceived exertion	3	2				
Do you have difficulties with the exercise? Please describe.	None	None				
Any Other Comments	Calf muscle ache on 20/08 after exercise which disappeared on 22/08	Nil				

Seniors Exercise Park Diary

Type of Exercise	Date of visit to the Seniors Exercise Park						
Time of Exercise							
Push up bar							
Pull ups							
Calf raises & finger							
Step-ups							
Hip Abduction							
Gangway							
Balance stool							
Balance beam							
Taps on platform							
Hip Extension							
Ramp and net							

Snake Pipe – Small Wave							
Snake Pipe – Big Wave							
Hand Roll							
Core Twister							
Shoulder arches							
Sit to stand							
Stairs							
Total duration spent at the exercise park							
Rate of perceived Exertion							
Do you have difficulties with the exercise? Please describe.							
Any Other Comments							

Appendix 9 : Interview guide - Experiences of older adults with mild balance dysfunction who participated in a supervised Seniors Exercise Park program progressing to independent practice (Chapter 7)

At follow-up after 18 weeks

- Why did you volunteer for the program?
- How did you find out about the program?
- What did you think about being involved in the program? Why was that?
- What did you think when using the equipment?
- Can you share with me any changes/improvements to how the program was run/organized?
- What motivates you to keep coming to this program? Why is that?
- What were the reasons for not coming for classes? Why so?
- What do you think about exercising in a group? How useful was it?
- Have you noticed any changes in your life after participating in Seniors Exercise Park program? If yes, what are the changes?
- Do you think you will continue your exercise park exercises independently? Why?
- What changes to this program would encourage you to continue your participation?
- Would you recommend Seniors Exercise Park program to others? Why?
- Do you have anything else to add about the program?

At follow-up after 24 weeks

If the participant answered **yes** to engaging in Seniors Exercise Park training independently:

- What do you think about completing the exercises on your own?
- What motivates you to keep doing exercises independently?

- What were some challenges you had with incorporating exercises in the park into your daily life?
- Were you able to find enough time to fit the exercise park into your week? Why or why not?
- What were your concerns when you were using the exercise park independently?
- What do you think helped increase your confidence using the exercise park on your own?
- What do you think about the availability of researcher to answer any queries at an allocated time at the Seniors Exercise Park?
- What do you think will encourage you to continue using Seniors Exercise Park independently beyond today?
- Most people do not do enough exercise. You are not in that category. Why is it you exercise? What makes you different?
- Have you noticed any changes in your life after participating in independent exercises?
- Do you have anything else to add?

If the participant answered **no** to engaging in Seniors Exercise Park training independently:

- Why did you not do the exercises in the park on your own?
- What factors prevented you from incorporating exercises in the park into your daily life?
- What do you think will encourage you to use the exercise park independently?
- Have you noticed any change in your performance since the last supervised session?
- Do you have anything else to add?

Appendix 10 : Participant information sheet - Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic (Chapter 8)

Curtin University

PARTICIPANT INFORMATION STATEMENT

HREC Project Number:	HRE2020-0271
Project Title:	Exploring older people's physical activity experiences during a pandemic (COVID-19): A qualitative study
Principal Investigator:	Dr. Elissa Burton, Senior Research Fellow, School of Physiotherapy and Exercise Science, Curtin University
Student researcher:	Michelle Ng
Version Number:	2
Version Date:	15 May 2020

What is the project about?

This is a study to find out your experiences and perceptions of being physically active before the coronavirus and now since you have been asked to practice social distancing. Social distancing is one of the measures recommended by experts and governments across the world to contain a pandemic. Social distancing is defined as "keeping space between yourself and other people outside of your home"[1] such as maintaining 1.5 metres away from others, avoid large gathering and crowded places.[2] Practicing social distancing may cause you to make changes to your routines including the type of physical activity you do or reduce your physical activity completely during this period of lockdown. Currently, there is limited research about the effects of a pandemic on older people being or continuing to be physically active.

Who is doing the research?

The project is being conducted by Michelle Ng, who is a Ph.D. student from Curtin University and will be supervised by Dr. Elissa Burton (an experienced Exercise Scientist) from Curtin University and Professor Keith Hill (an experienced Physiotherapist) from Monash University.

Why am I being asked to take part and what will I have to do?

We are looking for volunteers (aged 65 years and above), who speak and understand English and participate in at least 30 minutes of physical activities on most days of the week. If you agree to participate in this research, Michelle will call you (by phone) at a mutually agreed time to conduct the interview. The interview will take approximately 30 minutes. She will ask you questions about you (e.g. age and education) and your physical activity participation such as "what types of physical activity do you normally do?". She will audio record the interview so that she can concentrate on what you have to say and not be distracted by taking notes. After the interview a full written copy of the recording will be made. There will be no cost to you for taking part in this research and you will not be paid for taking part.

Are there any benefits to being in the research project?

There may be no direct benefit to you from participating in this research. Sometimes, people appreciate the opportunity to discuss their opinions. We hope the results of this research will allow us to add to the knowledge about older people's participation in physical activity and to help us identify strategies or future programs to help older people to be physically active who may need to be isolated due to their health requirements in the future.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

Apart from giving up your time, we do not expect that there will be any risks or inconveniences associated with taking part in this study. We have been careful to make sure that the questions in the interview do not cause you any distress. But if you feel anxious about any of the questions you do not need to answer them. Should some distress occur, the interview will be stopped, and a discussion about how you are feeling and what you could potentially do to feel better will occur. If this does not help, you can call the following support services (Refer to the list of support services) provided below or call your GP to discuss how you are feeling.

Support Services	Contact Number
1. Beyond Blue	1300 22 4636
2. Crisis Care Helpline	+61 8 9233 1111 or 1800 199 008 (Free call)
3. Lifeline	13 11 14

Who will have access to my information?

The information collected in this research will be de-identified (coded). We will remove identifying information on any data and replace it with a code. Only the research team has access to the code to match your name if it is necessary to do so. Any information we collect will be treated as confidential and used only in this project unless otherwise specified. The research team and the Curtin University Human Research Ethics Committee will have access to the information collected in this research. Electronic data will be password-protected and hard copy data will be stored in a locked cupboard at Curtin University.

The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed. You have the right to access, and request correction of, your information following relevant privacy laws. The results of this research may be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?

If you would like a summary of the results, please let Michelle know. We will e-mail you at the end of the project and let you know the results. Results will not be individual but based on all the information we collect and review as part of the research. We hope to publish the results in a peer-review journal article with a focus on older people. The results of this research project will be used by Michelle Ng to obtain a Doctor of Philosophy (Ph.D.) at Curtin University and are funded by Curtin University.

Do I have to take part in the research project?

Taking part in this research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. If you choose to leave the study, we will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

If you are interested in participating in this study or have any questions, please contact:
Ms. Michelle Ng, Ph.D. Student, Curtin University
Contact number: (08) 92664926, E-mail address: yokeleng.ng1@postgrad.curtin.edu.au
OR
Dr. Elissa Burton, Exercise Scientist, Curtin University
Contact number: (08) 92664926, E-mail address: E.Burton@curtin.edu.au

If you would like to take part in this research study, we will ask you to kindly e-mail back to us a statement of consent. By e-mailing us the statement of consent, you are telling us that you understand what you have read and what has been discussed and indicates that you agree to be in the research project and have your information be used as described above. Please take your time and ask any questions you have before you decide. You have been given a copy of this information sheet and the statement of consent.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2020-0271). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

REFERENCES

1. Centers for Disease Control and Prevention. Social Distancing. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html. Published 2019. Accessed 17 May, 2020.
2. Australian Government Department of Health. Physical Distancing for Coronavirus (COVID-19) https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/how-to-protect-yourself-and-others-from-coronavirus-covid-19/physical-distancing-for-coronavirus-covid-19. Published 2020. Accessed 17 May, 2020.

Appendix 11 : Participant consent forms

1. Consent form - Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment (Chapter 5)

Balance and mobility test for use in the home

Curtin University

CONSENT FORM

HREC Project Number:	HRE2019-0735
Project Title:	Evaluation of a modified version of the Community Balance and Mobility Scale (CBMS) for use in home assessment
Principal Investigator:	Dr. Elissa Burton, Senior Research Fellow, School of Physiotherapy and Exercise Science, Curtin University
Student researcher:	Ng Yoke Leng

- I have read, the information statement provided and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project and that I am free to withdraw at any time, without giving any reasons.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) – updated March 2014.
- I understand I will receive a copy of this Information Statement and Consent Form.

Consent to take part in future research
I agree to be contacted by the research team about future research projects.
Yes ☐ No ☐

Participant Name	
Participant Signature	
Date	

Declaration by researcher: I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	
Researcher Signature	
Date	

Note: All parties signing the Consent Form must date their own signature.

Participant Consent Form Version 2, 16/10/2019 *Page 1 of 1*

2. Consent form - Seniors Exercise Park program for older adults with mild balance dysfunction – A feasibility study (Chapters 6 and 7)

Seniors Exercise Park Programme for Older People — Curtin University

CONSENT FORM

HREC Project Number:	HE2019-0734
Project Title:	**Seniors Exercise Park (SEP) programme for older people with and without mild balance dysfunction**
Principal Investigator:	Dr. Elissa Burton, Senior Research Fellow, School of Physiotherapy and Exercise Science, Curtin University
Student researcher:	Michelle Ng

- I have read the information statement provided and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project and that I am free to withdraw at any time, without giving any reasons.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) – updated March 2014.
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Optional Consent for use of images
I consent to the use of visual images (videos and/or photos) in printed material (e.g. journal articles, reports, leaflets, news releases, newspaper articles), on websites, and in presentations (e.g. at seminars or conferences) involving my participation in this research.
Yes ☐ No ☐

I consent to the use of visual images (videos and/or photos) in printed material (e.g. journal articles, reports, leaflets, news releases, newspaper articles), on websites and in presentations (e.g. at seminars or conferences) involving my participation in this research **if the face is covered**.
Yes ☐ No ☐

Declaration by researcher: I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	
Researcher Signature	
Date	

Note: All parties signing the Consent Form must date their own signature

Participant Consent Form Version 1, 20/08/2019 — *Page 1 of 1*
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3. Consent form - Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic (Chapter 8)

Exploring older people's physical activity experiences during a pandemic (COVID-19): A qualitative study

Curtin University

Dear (add participant's name)

It was lovely to talk with you over the phone. Thank you for agreeing to participate in my research project on "Exploring older people's physical activity experiences during a pandemic (COVID-19): A qualitative study". Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2020-0271).

The purpose of the research is to find out your experiences and perceptions of being physically active before the coronavirus and now since you have been asked to practice social distancing. It will consist of an interview conducted over the phone for 30 minutes.

Attached with this e-mail is a copy of "The Participant Information Sheet". Read the information sheet for details about the research. You can e-mail or call me if you have any questions about the research.

If you are happy to volunteer for the research, please do the following:
1. Copy and paste the statement below. Type your name in the "[add name]".
2. **E-mail** the completed statement back to me.

Dear Michelle,

I [add name] have read and understood the information statement and consent to participate in this research project "Exploring older people's physical activity experiences during a pandemic (COVID-19): A qualitative study" and the interview to be audio recorded.

Regards,
[add name]

I look forward to hearing from you. Thank you. Have a good day ahead.

Appendix 12 : Ethics approval letters

1. Ethics office approval letter - Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment (Chapter 5)

Curtin University

Research Office at Curtin

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

28-Oct-2019

Name: Elissa Burton
Department/School: School of Physiotherapy and Exercise Science
Email: E.Burton@curtin.edu.au

Dear Elissa Burton

RE: Ethics Office approval
Approval number: HRE2019-0735

Thank you for submitting your application to the Human Research Ethics Office for the project **Evaluation of a modified version of the Community Balance and Mobility Scale (CBMS) for use in home assessment**.

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **28-Oct-2019** to **27-Oct-2020**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Ng, Yoke Leng	Student
Burton, Elissa	Supervisor
Hill, Keith	Supervisor

Approved documents:

Document

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the approved proposal and/or regulatory guidelines
   - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)

4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

Nil

This letter constitutes low risk/negligible risk approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Amy Bowater
Ethics, Team Lead

2. Ethics office approval letter - Seniors Exercise Park program for older adults with mild balance dysfunction – A feasibility study (Chapters 6 and 7)

Curtin University

Research Office at Curtin

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

28-Oct-2019

Name: Elissa Burton
Department/School: School of Physiotherapy and Exercise Science
Email: E.Burton@curtin.edu.au

Dear Elissa Burton

RE: Ethics Office approval
Approval number: HRE2019-0734

Thank you for submitting your application to the Human Research Ethics Office for the project **Seniors Exercise Park (SEP) programme for older people with and without mild balance dysfunction**.

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **28-Oct-2019** to **27-Oct-2020**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Burton, Elissa	CI
Ng, Yoke Leng	Student
Hill, Keith	Supervisor

Approved documents:

Document

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
    - proposed changes to the approved proposal or conduct of the study
    - unanticipated problems that might affect continued ethical acceptability of the project
    - major deviations from the approved proposal and/or regulatory guidelines
    - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)

4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

Nil

This letter constitutes low risk/negligible risk approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Amy Bowater
Ethics, Team Lead

3. Ethics office approval letter - Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic (Chapter 8)

Curtin University

Research Office at Curtin

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

29-May-2020

Name: Elissa Burton
Department/School: School of Physiotherapy and Exercise Science
Email: E.Burton@curtin.edu.au

Dear Elissa Burton

RE: Ethics Office approval
Approval number: HRE2020-0271

Thank you for submitting your application to the Human Research Ethics Office for the project **Exploring older people's physical activity experiences during a pandemic (COVID-19): A qualitative study**.

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **29-May-2020** to **28-May-2021**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Burton, Elissa	CI
Hill, Keith	Co-Inv
Ng, Yoke Leng	Student

Approved documents:

Document

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
    - proposed changes to the approved proposal or conduct of the study
    - unanticipated problems that might affect continued ethical acceptability of the project
    - major deviations from the approved proposal and/or regulatory guidelines
    - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)

4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

It is the responsibility of the Chief Investigator to ensure that any activity undertaken under this project adheres to the latest available advice from the Government or the University regarding COVID-19.

This letter constitutes low risk/negligible risk approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Amy Bowater
Ethics, Team Lead

Appendix 13 : Seniors Exercise Park stations used during supervised training sessions

Training sessions	Exercise stations
Even numbered training sessions (i.e., training session number 2,4,6,8,10,12,14,16,18,22)	Hip extension, stairs, sit to stand exercise, snake pipe (big wave), ramp and net, handroll, calf raises and finger steps, pull ups, gangway
Odd numbered training sessions (i.e., training session number 1,3,5,7,9,11,13,15,17,19,21)	Hip abduction, taps on platform, step ups, snake pipe (small wave), core twister, balance bean, balance stool, shoulder arches, push ups

Adapted from Ng, Y.L., Hill, K.D., Levinger, P., Jacques, A., & Burton, E. (2022). Seniors Exercise Park program for older adults with mild balance dysfunction – A feasibility study. *Disability and Rehabilitation*, Advance online publication, 1 – 12. https://doi.org/10.1080/09638288.2022.2112984.

Appendix 14 : Interview guide - Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic (Chapter 8)

1. What does physical activity mean to you?
2. Do you participate in any exercise groups away from home on a regular basis? If so, what is the nature of this physical activity? Frequency? Duration of each activity? Where do you do these activities? Who do you do these activities with? How many people are you normally doing these activities with?
3. Do you participate in any exercise with a therapist, trainer or exercise physiologist on a regular basis? If so, what is the nature of this physical activity? Frequency? Duration of each activity? Where do you do these activities? Who do you do these activities with? How many people are you normally doing these activities with?
4. Do you participate in physical activity at home regularly? If so, what is the nature of this physical activity? Frequency? Duration of each activity? Where do you do these activities? Who do you do these activities with? How many people are you normally doing these activities with? Do you use any equipment? What type of equipment do you use? Was it easy to purchase? Was it easy to use? Frequency? Duration?
5. Are you continuing to do all or some of these physical activities currently?
6. Have you noticed any detrimental physical effects of not continuing with the physical activity you were previously doing?
7. Have you noticed any detrimental effects on your mental health or well-being because you were not continuing with the physical activity you were previously doing?
8. How has COVID-19 affected your physical activity participation?

9. What has changed for you compared to before COVID-19?
10. Did you make any changes to your physical activity during any of the phases of restrictions of COVID-19?
11. How are you finding this?
12. What do you think you will do to your physical activity schedule over the coming months?
13. What motivates you to be physically active during this period?
14. List your top three strategies that you think can help support your physical activity participation during COVID-19?
15. What do you think you will do about your physical activity participation after the COVID-19 pandemic is over?

Appendix 15 : Copyright information

1. Copyright information to use the accepted (peer-reviewed) version of the manuscript (Effectiveness of outdoor exercise parks on health outcomes in older adults – A mixed-methods systematic review and meta-analysis - Chapter 4)

   Website: https://journals.humankinetics.com/page/copyright/copyright-and-permissions

In which ways may authors of a manuscript published in a Human Kinetics journal reuse their manuscript without first seeking permission from Human Kinetics?
With proper acknowledgment, authors may reuse all or part of their accepted manuscript in the following ways without first seeking permission:

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Which version of an author's manuscript does Human Kinetics describe with the phrase "accepted manuscript"?
The accepted manuscript is the version of the manuscript that has been through peer review and accepted by a journal editor for publication. It is not the final published version.

Are authors permitted to post their dissertation on ProQuest when the dissertation includes all or part of their accepted manuscript?
Yes, authors may post dissertations that include all or part of their accepted manuscript as long as the manuscript has been published; proper acknowledgment is made of its initial appearance in the journal; and the manuscript is in PDF or other image capturing format.

Are authors permitted to post a version of their manuscript on their own website or on websites/other electronic repositories controlled by their academic institution?
Yes, with proper acknowledgment (details below), authors may post their accepted manuscript on their own website or on websites/other electronic repositories controlled by their academic institution as long as the article has been published (either as Ahead of Print or in final form) and the manuscript is in PDF or other image capturing format.

2. Copyright information to use the accepted (peer-reviewed) version of the manuscript (Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment - Chapter 5)

   Website: https://academic.oup.com/journals/pages/self_archiving_policy_b

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This policy sets out the ways in which OUP journal authors can self-archive versions of their work on their own webpages, on institutional webpages, and in other repositories. Please be aware that policies and embargo periods may differ from journal to journal, so ensure that you have selected the correct journal policy (*Accepted Manuscript embargo period)

Article version	Personal website	Institutional or non-commercial subject based repository	Commercial platforms and social media
Authors Original Version (AOV)	At any time	At any time	At any time
Accepted Manuscript (AM)	After publication	After embargo period*	AM may not be posted, unless the website or repository has signed an agreement with OUP permitting re-use

3. Copyright information to use the accepted (peer-reviewed) version of the manuscript (Seniors Exercise Park program for older adults with mild balance dysfunction – A feasibility study - Chapter 6)

   Website: https://authorservices.taylorandfrancis.com/research-impact/sharing-versions-of-journal-articles/#

Accepted Manuscript (AM)

What is it?

This is the version of your manuscript after it's been through peer review, including any improvements resulting from that process, and has been accepted by the journal's editor.

When you receive the acceptance email from the Editorial Office, keep a copy of your AM for any future posting.

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To encourage citation of your work (and to help you measure its impact with article metrics), we recommend that you insert a link from your posted AM to the published article on Taylor & Francis Online with the following text:

"This is an Accepted Manuscript of an article published by Taylor & Francis in [JOURNAL TITLE] on [date of publication], available at: http://www.tandfonline.com/[Article DOI]."

4. Copyright information to use the accepted (peer-reviewed) version of the manuscript (Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic - Chapter 8)

   Website: https://authorservices.wiley.com/author-resources/Journal-Authors/licensing/self-archiving.html

Accepted (peer-reviewed) Version

The accepted version of an article is the version that incorporates all amendments made during the peer review process, but prior to the final published version (the Version of Record, which includes; copy and stylistic edits, online and print formatting, citation and other linking, deposit in abstracting and indexing services, and the addition of bibliographic and other material.

Self-archiving of the accepted version is subject to an embargo period of 12-24 months. The standard embargo period is 12 months for scientific, technical, medical, and psychology (STM) journals and 24 months for social science and humanities (SSH) journals following publication of the final article. Use our Author Compliance Tool to check the embargo period for individual journals or check their copyright policy on Wiley Online Library.

The accepted version may be placed on:

- the author's personal website
- the author's company/institutional repository or archive
- not for profit subject-based repositories such as PubMed Central

Articles may be deposited into repositories on acceptance, but access to the article is subject to the embargo period.

5. Copyright permission to use the Physical Activity Scale for the Elderly Questionnaire

RE: PASE survey

Healthcore-Media Mailbox <media@healthcore.com>
Sat 1/25/2020 5:23 AM
To: Elissa Burton <E.Burton@curtin.edu.au>
Cc: Michelle Ng <yokeleng.ng1@postgrad.curtin.edu.au>

Hi Elissa and Michelle,

Thank you for your email and so sorry for the delayed response. We are in the process of transitioning the PASE administration to HealthCore, as we were recently acquired. I am happy to confirm that if you have everything you need to use the PASE for your PhD student's research, she may go ahead and do so at no cost, since our payment processing is not yet live. If you need a formal letter for permission, please just let me know and I'll be happy to issue one, if you can provid me with the details of the study (study name, # of PASE administrations).

If you have any questions in the future, please don't hesitate to reach out.

Best,

HealthCore

Julia Coleman, *Project Manager, Digital Research Solutions*
HealthCore, Inc.
480 Pleasant Street, Watertown, MA 02472
(617) 972-3299
JColeman@HealthCore.com

6. Copyright permission to use the European Quality of Life-5D-5L (EQ-5D-5L) Questionnaire

General conditions for the registration ID : 32727

EuroQol - Registration <registration@euroqol.org>
Fri 11/8/2019 11:05 AM
To: Michelle Ng <yokeleng.ng1@postgrad.curtin.edu.au>

EQ-5D

Dear Ms. Yoke Leng Ng ,

We have registered your agreement with our Terms of Use regarding your request with tracking number: 32727 .

A team member will contact you as soon as possible to deliver the requested versions.

Yours sincerely,

Best regards,

Bernhard Slaap
Executive Director
EuroQol Research Foundation

EQ-5D

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Marten Meesweg 107 | 3068 AV Rotterdam The Netherlands

The EuroQoL Group

Certified Translation: EQ-5D-5L English version for Australia

This is to certify that a qualified language consultant recruited locally in Australia by Oxford Outcomes Ltd., and under contract to the EuroQoL Group Foundation adapted the EQ-5D-5L from the UK English 'source' version to English for Australia in 2009. Oxford Outcomes specialize in the cultural adaptation and linguistic validation of Patient Reported Outcome instruments and have considerable experience in this field in a wide range of therapeutic areas.

The Australian English version was produced following established EuroQoL Group methodology for this type of adaptation[1]. The process included a review of the source version by an in-country language consultant who was a native speaker of the target language, the introduction of modifications recommended by the language consultant and approved by a EuroQol reviewer, and testing of the modified version in cognitive debriefing interviews with 8 native Australian English-speaking respondents who were resident in Australia. Respondents were selected to cover a range of socio-demographic characteristics and included both patients and healthy individuals.

All steps in the adaptation process were taken in full cooperation with members of the EuroQoL Group's translation review team who reviewed reports provided by Oxford Outcomes after each stage of the process. All adaptation work was performed by members of the Australian English translation team to the best of their abilities as native speakers of Australian English, and as translators and researchers experienced in the field of health-related quality of life research. This version is, to the best of my knowledge, a valid and accurate adaptation of the corresponding original document.

Name: Rosalind Rabin

Title: Executive Officer, EuroQoL Foundation and member of the EuroQoL Group Translation Review Team

Signature:

Date: September 2011

[1] Herdman M, Fox-Rushby J, Rabin R, Badia X, Selai C. Producing other language versions of the EQ-5D. In: Brooks R, Rabin R, de Charro F (eds). The measurement and valuation of health status using EQ-5D: A European perspective. Kluwer Academic Publishers. 2003.

7. Copyright permission to use the Community Balance and Mobility Scale

   Website: http://www.tbims.org/combi/cbm

The CB&M has been adopted for use in clinical practice with other populations, for example people with multiple sclerosis, Parkinson's disease, acquired brain injury and stroke. Please see the Properties section for populations with whom the CB&M has been specifically validated.

Permission to use the CB&M is freely given but the co-investigators would appreciate hearing from users about the utility and application of the CB&M. Contact information is found in the left panel.

If you find the information in the COMBI useful, please mention it when citing sources of information. The information on the Community Balance and Mobility scale may be cited as:

Howe, J, Inness EL, & Wright, V. (2011). The Community Balance & Mobility Scale. *The Center for Outcome Measurement in Brain Injury.* http://www.tbims.org/combi/cbm (accessed February 1, 2021).

8. Copyright permission to use the Seniors Exercise Park equipment images

Pazit Levinger <P.Levinger@nari.edu.au>
Fri 11/22/2019 12:37 PM
To: Michelle Ng <yokeleng.ng1@postgrad.curtin.edu.au>

19 attachments (3 MB)

1 Hand Roll.jpg; 1 Pull Ups.jpg; 2 Balance Stool.jpg; 2 Calf Raises.jpg; 2 Finger Steps.jpg; 3 Core Twister.jpg; 3 Gangway.jpg; 4 Balance Beam.jpg; 4 Snake Pipe - Big Wave.jpg; 5 Shoulder Arches.jpg; 5 Snake Pipe - Small Wave.jpg; 6 Ramp Net Climb.jpg; 6 Step Up.jpg; 7 Push Ups.jpg; 7 Sit to Stand.jpg; 8 Hip Extension.jpg; 8 Stairs.jpg; 9 Hip Abduction.jpg; 9 Toe Tap.jpg;

Hi Michelle,
The images are attached.

In terms of acknowledgment -
when you use them for any printed material/presentations etc - you can just simply put at the bottom something like that
Graphic images provided by the National Ageing Research Institute (ENJOY project https://www.nari.net.au/enjoy)

For any publications you can just use our reference - provided with permission
Levinger P et al. Exercise interveNtion outdoor proJect in the cOmmunitY for older people – the ENJOY senior Exercise Park project translation research protocol. BMC Public Health, 2019 19:933

And if you are unsure , just ask!

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cid:image003.gif@01CFA59B.00E0CC40
Adjunct Associate Professor | The Institute for Health and Sport (IHES) | Victoria University
https://www.nari.net.au/enjoy

9. Copyright permission to use the table to determine older adults with mild balance dysfunction

PERMISSION TO USE COPYRIGHT MATERIAL AS SPECIFIED BELOW:

"Table 2: Cut-Off Scores for Classification of Mild Balance Dysfunction in the Present Study, page 590" from Williams, S., Meyer, C., Batchelor, F., & Hill, K. (2015). Exercise for mild balance dysfunction: research into practice. *Journal of Aging and Physical Activity, 23*(4), 588-596. https://doi.org/10.1123/japa.2014-0182

I hereby give permission for **Ng Yoke Leng** to include the abovementioned materials in her higher degree thesis for Curtin University, and to communicate this material via the espace institutional repository. This permission is granted on a non-exclusive basis and for an indefinite period.

I confirm that I am the copyright owner of the specified material.

Signed:

Name: Martha Gullo

Position: Permissions Director

Date: November 9, 2020

Appendix 16 : Authorship contribution statement - Chapter 4

Ng, Y.L., Hill, K.D., Levinger, P., & Burton, E. (2020). Effectiveness of Outdoor Exercise Parks on Health Outcomes in Older Adults – A Mixed-Methods Systematic Review and Meta-Analysis. *Journal of Aging and Physical Activity*, 29(4), 695-707. https://doi.org/10.1123/japa.2020-0031.

	Conception and design	**Acquisition of data and method**	**Data conditioning and manipulation**	**Analysis and statistical method**	**Interpretation and discussion**	**Final approval**	**Total % contribution**
Co-Author 1: Ng Yoke Leng	✓	✓	✓	✓	✓	✓	55%
Co Author 1 Acknowledgment: I acknowledge that these represent my contribution to the above research output and I have approved the final version. Signed:							
Co-Author 2: Keith D. Hill	✓	✓		✓	✓	✓	15%
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Co-Author 3: Pazit Levinger					✓	✓	5%
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Co-Author 4: Elissa Burton	✓	✓	✓	✓	✓	✓	25%
Co-Author 4 Acknowledgment: I acknowledge that these represent my contribution to the above research output and I have approved the final version. Signed:							

Appendix 17 : Authorship contribution statement - Chapter 5

Ng, Y. L., Hill, K. D., Jacques, A., & Burton, E. (2021). Reliability and validity of a modified version of the Community Balance and Mobility Scale (CBMS-Home) for use in home assessment. *Physical Therapy*, 101(8), 1-10. https://doi.org/10.1093/ptj/pzab134.

<table>
<tr><th></th><th>Conception and design</th><th>Acquisition of data and method</th><th>Data conditioning and manipulation</th><th>Analysis and statistical method</th><th>Interpretation and discussion</th><th>Final approval</th><th>Total % contribution</th></tr>
<tr><td>Co-Author 1:
Ng Yoke Leng</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>60%</td></tr>
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Angela Jacques</td><td></td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td><td>5%</td></tr>
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Appendix 18 : Authorship contribution statement - Chapter 6

A Seniors Exercise Park program for older adults with mild balance dysfunction – A feasibility study. *Disability and Rehabilitation*, Advance online publication, 1-12, https://doi.org/10.1080/09638288.2022.2112984

	Conception and design	**Acquisition of data and method**	**Data conditioning and manipulation**	**Analysis and statistical method**	**Interpretation and discussion**	**Final approval**	**Total % contribution**
Co-Author 1: Ng Yoke Leng	✓	✓	✓	✓	✓	✓	50%
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Co-Author 2: Keith D. Hill	✓	✓			✓	✓	17%
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Co-Author 3: Pazit Levinger	✓				✓	✓	8%
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Co-Author 4: Angela Jacques				✓	✓	✓	8%
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Co-Author 5: Elissa Burton	✓	✓			✓	✓	17%
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Appendix 19 : Authorship contribution statement - Chapter 7

Experiences of older adults with mild balance dysfunction who participated in a supervised Seniors Exercise Park program progressing to independent practice

<table>
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<tr><td>Co-Author 1:
Ng Yoke Leng</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>60%</td></tr>
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<tr><td colspan="8">Co-Author 2 Acknowledgment:
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Elissa Burton</td><td>✓</td><td>✓</td><td></td><td>✓</td><td>✓</td><td>✓</td><td>25%</td></tr>
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Signed:</td></tr>
</table>

Appendix 20 : Authorship contribution statement - Chapter 8

Ng, Y. L., Hill, K. D., & Burton, E. Exploring physical activity changes and experiences of older adults living in retirement villages during a pandemic. *Australasian Journal on Ageing*, *41*, e103-e111, https://doi.org/https://doi.org/10.1111/ajag.12963.

	Conception and design	**Acquisition of data and method**	**Data conditioning and manipulation**	**Analysis**	**Interpretation and discussion**	**Final approval**	**Total % contribution**
Co-Author 1: Ng Yoke Leng	✓	✓	✓	✓	✓	✓	55%
Co Author 1 Acknowledgment: I acknowledge that these represent my contribution to the above research output and I have approved the final version. Signed:							
Co-Author 2: Keith D. Hill	✓	✓		✓	✓	✓	20%
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Co-Author 3: Elissa Burton	✓	✓		✓	✓	✓	25%
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