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A comparison of the effectiveness of two different exercise interventions in reducing the risk of falling in older adults in Gauteng

Hannah Jade Raath

Student number: 0414323H

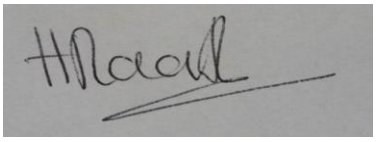
Dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Msc (Med) in Sport and Exercise Science.



Johannesburg, 2015

Declaration

I, Hannah Jade Raath, declare that this dissertation is my own work. It is being submitted for the degree of Master of Science in Biokinetics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.



(Signature of candidate)

Signed on the 20th of August 2015

Master of Science in Biokinetics

Publications and presentations

Presentation 1:

A comparison of the effectiveness of two different exercise interventions in reducing the risk of falling in older adullts in Gauteng.

5th Annual Alzimer's SA seminar, 10 September 2014 (Appendix A).

Presentation 2:

Fall prevention, balance and exercise prescription in older adults.

16th Congress of the National Osteoporosis Foundation of South Afrcia, 25 October 2014 (Appendix A).

Publication 1:

Paper sumbitted to the Journal of Geriatric Physcial Therapy: "Comparing the effectiveness of a general exercise program and a dynamic balance and stepping program on reducing falls risk outcomes in older adults". (Appendix A)

Acknowledgements

I would like to thank the following people for their contribution to this dissertation:

My supervisor, Estelle Watson, has given me endless support, patience, guidance and encouragement. She has inspired me to continue asking questions.

Professor Elena Libhaber, for her guidance and assistance with the statistical analysis.

My husband, Sergio Botelho, has held the fort, while I have spent my time reading, debating and writing. He kept me going during days when I wasn't sure where I was going.

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Definition of terms (nomenclature)

Fall: “Unintentionally coming to the ground or some lower level and other than as a consequence of sustaining a violent blow, loss of consciousness, sudden onset of paralysis as in stroke or an epileptic seizure” [1].

Fall risk factors: Features that contribute towards the incidence of a fall [2].

Physical activity: This refers to any activity that has an energy cost, such as housework, shopping, gardening and structured exercise programmes [3].

Exercise: Refers to planned, structured and repetitive movement that is designed to improve or maintain one or more components of physical fitness [4].

Strength training: These are specific exercise programmes that involve concentric, eccentric, and isometric muscle contraction and include bilateral and unilateral single and multiple-joint exercises [4].

Endurance/aerobic training: These are exercises that stimulate the cardio vascular system, and include activities such as, walking, running, climbing stairs, cycling, rowing, and swimming [5].

Activities of daily living: These comprise of bathing, dressing, toileting, transferring, continence, and eating, and are listed in order of increasing severity of disability [6].

Mini-Mental State Examination: A commonly used instrument for the assessment of cognitive function; including dementia and cognitive impairment [7].

Sarcopenia: “Age related decrease of skeletal muscle mass and function” [8].

Contraindications: For some individuals the risks of exercising outweigh the benefits, and this is due to certain signs or symptoms [9].

Abbreviations, acronyms and units

ACSM: American College of Sports Medicine

AHA: American Heart Association

ANOVA: Analysis of variance

BBS: Berg Balance Scale

BPM: Beats per Minute

Cm: Centimetres(s)

CONSORT: Consolidated Standards of Reporting Trials

CV: Cardio Vascular

DBSG: Dynamic Balance and Stepping Group

FES-I: Falls Efficacy Scale- International

FICSIT: Frailty and Injuries: Cooperative Studies of Intervention Techniques

FTSST: Five Times Sit to Stand Test

GEG: General Exercise Group

HREC: Human Research Ethics Committee

Kg: Kilogram(s)

Kg/m^2: Kilogram per square meter

mmHg: Millimetres of Mercury

n: Sample Size

N: Whole Sample Size

PARQ: Physical Activity Readiness Questionnaire

s: Seconds

SD: Standard Deviation

TUG: Timed up and go

US: United States

Abstract

Background: The development and implementation of effective strategies to prevent falls in older adults is an urgent global health issue. Various exercise interventions have successfully reduced fall risk, but many have used non–specific exercise programmes, making it difficult to assess which physical components are responsible for the favourable outcomes. In addition, little is known on exactly how long the exercise interventions need to continue. Therefore, the aim of this study was to assess the effectiveness of two fall prevention exercise programmes; a general exercise programme and a dynamic balance and stepping exercise programme on fall risk outcomes in older adults. In addition to this, comparisons between the two programmes were made and differences between 8 weeks and 12 weeks of the intervention were determined.

Methods: Thirty two participants over the age of 65 years were randomly assigned to one of two exercise intervention groups. Participants attended one hour group classes twice a week. Fall risk outcomes were measured at baseline, and after 8 and 12 weeks of the exercise intervention. Outcomes included the five times sit to stand test, timed up and go test, fall efficacy scale- International, Berg balance scale, Biodex overall stability index and the Biodex modified clinical test of sensory integration and balance. Statistical analysis included multifactorial ANOVA on log transformed data and the Mann-Whitney test for non-parametric data.

Results: Although both groups showed reduction in fall risk after the exercise interventions, results indicated the dynamic balance and stepping exercise programme had more of an effect on the functional strength (five times sit to stand test) and functional balance outcomes (Berg balance scale) than the general

exercise programme. Within group statistical differences were noted between 8 and 12 weeks for the dynamic balance and stepping group for the five times sit to stand test ($p= 0.02$) and between group differences at 12 weeks for the Berg balance scale ($p= 0.04$), for the same group. The general exercise group however, did perform better in the mobility outcome variable; the timed up and go test, with significant differences occurring between 8 and 12 weeks ($p= 0.04$).

Conclusions: Both exercise groups were effective in reducing the risk of falls in the older adults. However, incorporating dynamic balance and stepping into the exercise programme was more effective in improving specifically functional strength and balance. In addition, all differences were noted between 8 and 12 weeks, thus programmes that aim at improving fall risk outcomes should be at least 12 weeks in length. Future studies should compare long term outcomes and fall rates in response to these two exercise programmes.

Chapter One

Introduction

1.1 Introduction

Improved health care and longevity have led to an unprecedented growth in the ageing population [10]. Since falls in older adults lead to significant morbidity as well as mortality and are considered a major burden on society [11], we need to seriously consider these implications as the global population rapidly ages. One in three individuals over the age of 65 falls once a year, and of those who fall, half will fall recurrently [12]. By the age of 80 the proportion of older adults who fall annually increases to 50% [13,26].

Falls are not random events and various risk factors can contribute towards fall incidence. Intrinsic risk factors such as age, certain chronic conditions like osteoporosis, diabetes and arthritis, functional abilities, balance problems, muscular weakness and slow reaction time, all increase the risk of falling [14]. Extrinsic risk factors like tripping dangers, unstable furniture, poor lighting and lack of grab bars and stair railings, also contribute to this issue. The risks of falling increases with the number of risk factors present [2].

Various exercise interventions have been successful in reducing fall risk and falls in older adults by improving physiological impairments [14]. Interventions such as exercise programmes aimed at modifying risk factors such as lower-body weakness, gait and balance problems have been shown to be effective [15]. One such programme is the Otago exercise programme, which includes muscle strengthening

and balance retraining exercises that are individually prescribed by trained instructors for older adults to do at home, and which has decreased falls and fall related injury by 35% [16]. In addition, the central FICSIT (Frailty and Injuries: Cooperative Studies of Intervention Techniques) meta-analysis of recent research found that exercise programmes are successful in reducing falls [13]. More specifically, the pooled data from 44 trials with 9603 participants have indicated that the exercise programmes that included balance training, but not any other forms of exercise, lower fall risk by 17% [17].

1.2 Problem statement

Exercise interventions for reducing falls has been the topic of much recent research [3, 15]. There is a need to preserve the physical functioning, decrease physical limitations and disability and reduce falls in this vulnerable, fast growing older adult population [24]. Although there is consensus that exercise is beneficial to reduce falls, exercise comes in many forms, and the large variety of exercise programmes used for fall prevention makes it difficult to understand exactly which combination of exercises are key and therefore most important in improving fall risk outcomes [14]. Some exercise interventions, or elements thereof, seem to be more effective in reducing fall risk than others [12]. Due to the large variety of exercise programmes and efficacy of some exercise programmes, studies have discussed that there are no clear prescriptive guidelines that indicate precisely which type, or combination of exercise is most effective [18]. Very few studies have compared the efficacy of different types or combinations of exercise, and this has also resulted in guidelines being vague and unspecific [18]. Gardner et al., 2000 reported two main varieties of exercise programmes that seem to exist within fall prevention programmes are

dynamic balance training, and general strength exercise. Determining if differences occur between these two lines of thinking will assist in understanding which type or combinations of exercise are more effective between these two main varieties. This then may assist in getting closer to understanding what the characteristics of the most effective exercise programmes are.

If a consensus, of which type or combination of exercises that is most effective, is reached, exercise prescription guidelines would become clearer. In effect this will allow for a better understanding of the mechanisms of rehabilitation that should make up the ideal programme prescription for fall prevention and therefore clinicians to be able to prescribe the most suitable and effective exercises to at risk older adults [14].

In addition research has shown that little is known on how long the exercise interventions should run for [144], therefore fall risk outcomes at different time points, within an exercise intervention, need to be compared. This will allow for an understanding of where the change in outcomes occurs, and therefore guidelines will be able to suggest how long interventions need to continue for.

1.3 Research aim

This study therefore aims to assess the effectiveness of two fall prevention exercise programmes for apparently healthy adults over the age of 65 years. One exercise programme is a general exercise programme according to the guidelines for older adults set out by the American College of Sports Medicine (ACSM) [5] and the second programme is a dynamic balance and stepping programme, which is largely based on two protocols; a study by Nnodim et al., (2006) as well as a comprehensive balance and mobility training programme [19, 20]. Thereafter the effectiveness of the

two exercise programmes will be compared to one another, to determine if one programme had more of an effect on fall risk outcomes than the other. Lastly the study will compare differences in fall risk outcomes in both groups between 8 weeks and 12 weeks of the intervention to measure where the change in outcome measures occurs.

1.4 Study objectives

- To compare the effects of the two different interventions on the following fall risk outcome variables:
    1. Five times sit to stand test
    2. Timed up and go test
    3. Fall efficacy scale- International
    4. Berg balance scale
    5. Biodex overall stability index
    6. Biodex modified clinical test of sensory integration and balance
- To determine the effects of a general exercise programme on fall risk and fear of falling in older adults.
- To determine the effects of a dynamic balance and stepping exercise programme on fall risk and fear of falling in older adults.
- To determine if an 8 week exercise intervention or a 12 week intervention would be most effective in improving fall risk outcomes in older adults.

1.5 Study hypothesis

- A dynamic balance and stepping exercise intervention is more effective than a general exercise intervention in terms of reducing fall risk in older adults.

1.6 Structure of dissertation

This dissertation begins with a review of the literature, wherein the consequences of an ageing population, the incidence of falls, fall risk factors as well as the injuries and

associated concerns of falling are discussed. Fall risk factors and assessing the risk of falls are analysed; physical activity in older adults, including recommended interventions for reducing falls are also explained. Thereafter the study design and methodology are deliberated, in which the outcome measures and exercise interventions are detailed. The results of the study are recorded, before the discussion chapter, in which the relevance and implications of the findings are highlighted. Lastly, any possible limitations are included as a recommendation for future research.

Chapter Two

Literature review

2.1 The ageing population

Global studies have indicated that there has been an unprecedented growth in the ageing population; this is mostly due to improved healthcare and longevity [10]. Life expectancy in developed countries, for people 65 years and older, is approximately 82 years for men and 86 years for women. In fact, it is estimated that soon the number of adults over the age of 65 years is set to overtake the amount of children under the age of 5 years [10]. By 2050 the global geriatric population is expected to rise to more than 1.2 billion people with about 840 million of these people in developing countries. The older population is living longer; the amount of Americans in the 65-74 year age group was 8 times larger (18.4 million) in 2000 than in 1900. Similarly, the 75-84 year age group was 16 times larger (12.4 million) and those aged 85 years and older was 34 times larger in the year 2000 compared to 1900 [21]. On one hand an ageing population represents a human success story, but on the other hand it has major economic and social implications on families, communities and healthcare systems [10, 22].

The increased burden on global health care resources is seen, for example, in the amount of times older adults (65 years and older) need to be seen by a doctor. On average this age group visited a doctor 6.5 times a year for those aged between 65-74 years, and 7.7 times a year for those over the age of 75 years. This is compared to only 3.9 annual doctors' visits for adults between the ages of 45-64 years old [23]. This older adult age group is experiencing an increased incidence of chronic

diseases, cancer, vision, hearing loss as well as dementia. Even though these diseases are not always immediately life threatening, for optimal outcomes they require expert management and often on-going treatment [21]. Therefore healthy ageing is a fundamental factor in reducing the burden of disease and disability associated with ageing [24].

2.2 The incidence of falls in older adults

Falls in older adults are a serious and unfortunate common problem. For example, 30% of people aged 65 and older fall each year [25], and this figure increases with age to 50% for adults over the age of 80 years [13, 26]. A South African study indicated similar results for adults over the age of 65 years, with the prevalence rate of falls in that sample being 26% [27]. Some studies have found that these figures might in fact be under estimates, due to many falls not being reported [28]. A systematic review done in 2008 reported that generally the rate of falls is 1.2 per year for the older adult population [17]. In addition, fall rates in women (40%) are higher than in men (28%) [1]. Kalula (2012) reported a large discrepancy in the incidence of falls within different ethnic sub-samples in South Africa. The results indicated the rate of falls for whites was 42.9%, 34.4% for coloureds and 6.4% for black Africans. These findings were attributed to differences in characteristics of the ethnic sub-samples; for example medical history, medication use, and whether they engaged in manual labour during their working life [27].

2.3 Injuries and consequences associated with falls

As the proportion of older adults grows, fall-related injuries and the consequences of falls affect many older adults and their families. Depending on the population, the

number of older people who suffer from a fall-related injury is 22-60% [1]. Of those that fall, 20-30% will suffer from injuries that are considered moderate; these injuries may reduce mobility and independence as well as increase the risk of premature death [29]. Ten to fifteen per cent of reported fall-related injuries are considered serious injuries; with 2-6% being fractures. Approximately 0.2-1.5% of those fractures are of the hip, which is considered the most serious in terms of mortality and morbidity [30]. In adults over the age of 75, falls account for 70% of accidental deaths [31]. For example, Kochanek et al., (2002) found that falls in the United States caused approximately 38% of unintentional injury deaths [32]. Every hour, one older adult (over 65 years), in the United States dies and 183 are treated in emergency departments for fall-related injuries [2]. In addition, falls in older adults are the most common cause of injury and hospitalisation for trauma [33]. For example, in 2002, 1.6 million older adults sought treatment in US hospitals emergency department, and of these 388 000 needed to be hospitalised due to their injuries. Furthermore, mortality and morbidity rates are high following a fall, particularly if there has been a hip fracture. Indeed, up to 20% of these patients die within a year after their fracture [34], and of those who survive, many often experience substantial disability and decreased quality of life [35]. There has been a steady increase in hospitalisation admissions for hip fractures in older adults (Figure 1). Indeed, Popovic (1999) reported that hospital admissions for hip fractures have risen from 230 000 in 1988 to 330 700 in 1999 [36]. Many hip fracture patients are discharged into a nursing home after hospitalisation [36] and between 15%-25% of previously independent older adults need to remain institutionalised for at least a year following their fall [37].

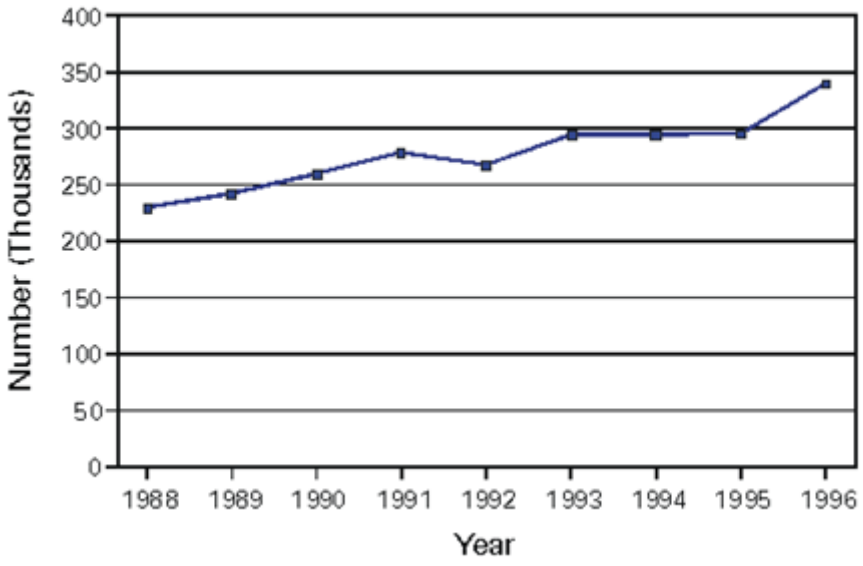

Figure 1: Estimated number of adults aged ≥65 years who were admitted for hip fractures in the United States between the years 1988-1996 [36].

Another grave consequence of falling is the long lie; which is when the faller remains on the ground for an hour or longer after a fall. A long lie is an indication of weakness and illness and is associated with dehydration, hypothermia, muscle injury, pneumonia and increased fear of falling. Half of the older adults who remain on the floor for an hour or more will die within 6 months [30]. The high incidence, and consequences, of falls in older people, together with the growth of the older adults population; results in many social and economic implications for this population [38].

2.4 Economic implications: The cost of falls

Falls in older adults are associated with high injury and morbidity as well as loss of independence and together these factors have major financial consequences. A fall-related injury is one of the 20 most expensive medical conditions among community-dwelling older adults [39]. The cost of falls includes direct costs (hospital care, nursing, rehabilitation, home modifications, doctor's services and medical equipment) as well as indirect costs (carer costs, patient morbidity and mortality

costs) [1]. Among community dwelling older adults, hospitalisation accounts for 65% of direct medical costs, 10% of costs were for medical office visits and home health care, 8% for hospital visits, 7% for emergency rooms visits and 1% each for prescription medication and dental visits [40].

In a study by Stevens et al., (2006), 10 300 fatal and 206 million non-fatal fall-related injuries reported in the US. The estimated direct medical costs for these injuries amounted to $2 million dollars for fatal and $19 billion dollars for non-fatal falls [41]. In addition, Finkelstein et al., (2005) examined the same cases and estimated that medical costs alone (omitting the nursing home costs) totalled $12.8 billion [42]. Although a search of the literature on cost of falls in South Africa yielded no research, projections made by Englander et al., (1996) indicate that the annual direct and indirect cost of falls will amount to $43.8 billion in the United States by 2020 [43]. One study reported that the average health care cost for treating fall-related injuries in older adults ages 72 and older was $19 440. This amount included hospital, nursing home, emergency room and home health care, but excluded physician fees [44]. Another study in 2002 reported that Medicare's (A US national social insurance programme) costs per fall ranged between $13 797 and $20 450 (R162 618- R241 033) [28]. It has also been reported that fall incidence and medical costs increase with age and that these costs are nearly 20% higher for women than for men [41].

Hip fractures are the most severe and costly fall-related injury. In the US, hospitalisation due to hip fractures accounts for 44% of health care costs [45]. It is projected that by 2040 the total annual cost of hip fractures will reach $240 billion, but these costs do not include the long term consequences of these injuries, such as disability, functional restrictions, decreased productivity and reduced quality of life [46,

47]. Therefore, injuries sustained from falls create a significant financial burden [2] and this underscores the need for effective interventions for fall prevention [41].

2.5 Psychological implications of experiencing a fall

In addition to the physical injuries, there are various psychological issues that result from a fall. Many people who fall, irrespective of whether they sustained an injury or not, will develop a fear of falling [48]. Post-fall anxiety syndrome occurs when an individual develops an overcautious fear of falling, and goes on to reduce activity levels. This in turn contributes to further deconditioning, muscle weakness and abnormal gait, and may actually increase the risk of falls [11]. Furthermore, there appears to be a strong association between fear of falling and experiencing future falls, irrespective of when the fall occurred. The vicious cycle becomes imminent as a fear of falling leads to health deterioration, decreased physical and social functioning and loss of independence [49].

In addition, falls have an impact on confidence, and loss of confidence is directly linked to the physical impact of a fall [50]. Loss of confidence in older adults can result in them prematurely relocating to long term care such as nursing homes. A study conducted by Tinneti and Williams (1997) found that 12% of older adults who experienced a fall will, as a result, require long term nursing home care [51]. Older adults who fall often don't want to leave their house, or they don't want to leave their house on their own, which in turn worsens the sense of isolation and loneliness [50].

Falls in older adults, regardless of their cause have significant physical, economic and psychological implications on those who fall, as well as their families.

Understanding these implications needs to be prioritised, so that the ever increasing global older adult population can be appropriately cared for.

2.6 Strategies for recovery from a fall and mechanisms of falls

In order to try and understand factors that are involved in restoring balance during a fall; kinematic, kinetic and neuromuscular responses associated with recovery from a fall or a stumble have been studied. Three common recovery strategies have been identified [52]:

1. The lowering strategy: During this strategy the tripped foot is immediately lowered to the ground on the near side of the obstacle. The tripped foot is the support limb while the other limb executes the first recovery step across the obstacle.
2. The elevating strategy: In this strategy the tripped foot is the recovery limb as it is lifted over the obstacle as a continuation of the original step. The contralateral stance limb will be flexed across multiple joints and this limb will act as the support limb during the recovery step.
3. The reaching strategy: The same principles apply with this strategy as in the elevation strategy, except flexion occurs only at the hip on the recovery limb

Pavol et al., (2001) also described three mechanisms of falling that they observed in their research [52]:

1. During-step fallers, who respond to a trip with a lowering strategy and fall before completing their recovery step.

2. After-step fallers also respond to a trip using a lowering strategy and are able to execute a successful recovery step; however they proceed to fall after the subsequent follow through step.
3. Final fallers use an elevation strategy and manage to successfully execute numerous steps after the recovery step before finally falling.

Figure 2 illustrates the three mechanisms of falling as described by Pavol et al., (2001). Images A-C are the average body states at the time of support limb (or tripped foot) loading. Images D-F show the recovery foot ground contact for subjects who successfully recovered from the fall using the lowering strategy (shown in A and D), during-step fallers (shown in B and E) and after step fallers (shown in C and F) [52].

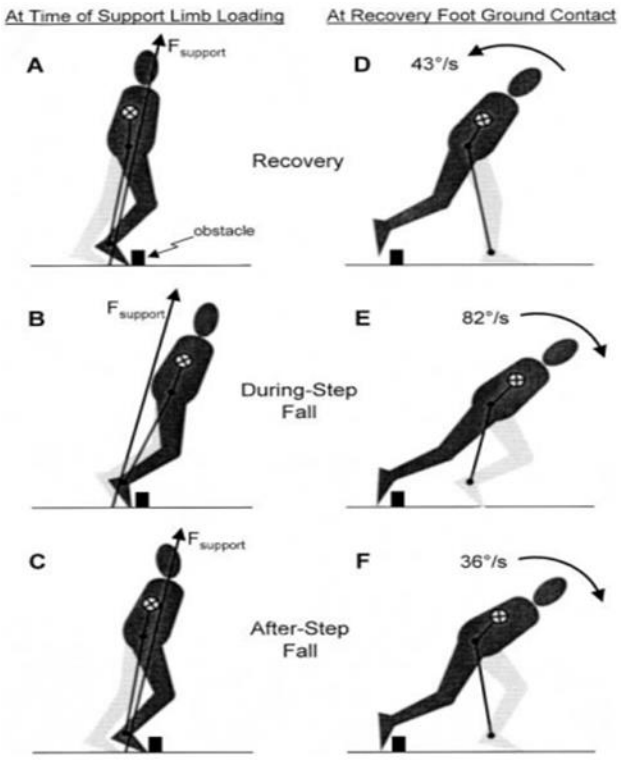

Figure 2: Mechanisms of falling [52].

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Understanding mechanisms of falling and associated strategies for recovery is important in fall prevention. If strategies for improving reaction time and recovery step ability could be implemented in fall prevention exercise programmes, recovery from a fall-like situation may increase.

2.7 Fall risk factors

In addition to understanding falls, identifying persons most at risk of falling is important in order to maximise the effectiveness of any proposed intervention. Falls often happen as a result of dynamic interaction of risk factors. Risk factors can be broadly classified into two categories [26]:

2.7.1 Intrinsic fall risk factors

Intrinsic risk factors are factors that originate with the individual, and they include:

1. History of falls: this is associated with an increased risk of falling [53, 54].
2. Age: with increasing age, the incidence of falls also increases [55, 56].
3. Gender: fall rates in women are higher (40%) than those in men (28%) [1].
4. Living alone: even though it is presumed that older individuals that live alone may have better functional ability than those living with family, injuries and outcomes following a fall may be worse if they live alone. This is especially true if the person is unable to get up off the floor, which could result in consequences such as hypothermia, dehydration, bronchopneumonia and the development of pressure sores [57].

5. Ethnicity: Studies from the United Kingdom and the United States report that the Caucasians fall more frequently than Afro-Caribbeans, Hispanics or South Asians [54, 58].

6. Medicines: Benzodiazepine (sedative, hypnotic, anti-anxiety, anticonvulsant, and muscle relaxant medication) use in older adults increases risk of hip fracture and falls at night by up to 44% [59]. This high risk of falling associated with these types of medication is due to the common side effects, which are ataxia (poor co-ordination), lethargy, dizziness, postural disturbances and diminished motor co-ordination [60]. In addition, risk of falling is also significantly increased with the use of medications such as psychotropics, which is an anti-arrhythmic medication, digoxin, diuretics [61] and sedatives [53]. With the progression of managing many chronic diseases, the number of prescribed medications has increased. This however, has increased risk of falling, as it has been established that if a person is on more than four medications, regardless of the type, their risk of falling will be higher than those on less than four prescribed medications [55, 62, 63].

7. Medical conditions: The incidence of falls increase with rising chronic disease burden [64, 65]. Fall risk is increased by 32% by medical conditions such as circulatory disease, chronic obstructive pulmonary disease, arthritis and depression. Loss of peripheral sensation also increases risk if falling [66].

8. Impaired mobility, balance and gait: A fundamental component of maintaining balance is the ability of a muscle to generate sufficient force [67]. After the age of 30, strength and endurance decline by 10%

per decade and muscle power decreases by 30% per decade; this results in physical functioning reducing below the threshold and performing activities of daily living becomes difficult and ultimately impossible [68]. When function declines sufficiently (due to a decline in strength, endurance and muscle power) one is unable to prevent a slip, trip or stumble, and this results in a fall. Other mobility and gait impairments that increase fall risk include: gait and balance deficit and the use of assistive devices, any lower extremity disability (loss of strength, orthopaedic abnormality or poor sensation), and difficulty rising from a chair [68, 69].

9. Sedentary behaviour: Those who fall are generally less active. Inactivity results in further atrophy of muscle around joints that are not used [68]. However, it is important to note the complex relationship between risk of falls and activity levels. In fact, some studies suggest a U-shape association between the two, and that is, the most inactive people and the most active people are at highest risk of experiencing a fall [69, 70].
10. Psychological status: There is a strong association between fear of falling and poor postural stability [71], slower walking speed, muscle weakness [72], poor self-rated health and reduced quality of life [73]. Up to 70% of recent fallers and up to 40% of those not reporting recent falls admit fear of falling [73]. Up to 50% of people who are scared of falling limit or avoid social and physical activities due to their fear [53].
11. Nutritional deficiencies: A low body mass index can suggest malnutrition, and this is associated with an increased risk of falling [74].

Vitamin D deficiency is specifically common in older adults living in residential care facilities, this deficiency can lead to abnormal gait, muscle weakness, and reduced bone density [75].

12. Impaired cognition: There is a strong correlation between cognitive impairment (even relatively modest) and risk of falling. For example, a score of <24 on the Mini-Mental State Examination is associated with increased risk [69]. Older adults with diagnosed dementia, and who live in residential care facilities, fall twice as often as those with normal cognition [76].
13. Visual impairments: The following visual impairments contribute to an increased risk of falls: impaired depth perception, deficiency in visual acuity, reduced contrast sensitivity, reduced visual field, cataract, glaucoma and macular degeneration [77]. Multifocal lenses may also contribute to increasing fall risk. For example, a study by Lord et al., 2006 describes how multifocal lenses reduce depth perception and edge contrast sensitivity, making it difficult to detect obstacles in the environment [78].
14. Foot problems: Difficulty in balancing may be as a result of bunions, toe deformities, ulcers, deformed nails and general pain in walking, all of which contribute to risk of falls [53].

2.7.2 Extrinsic fall risk factors

Extrinsic risk factors are factors outside the person and they include:

1. Environmental hazards: These include factors like poor lighting, slippery floors and uneven surfaces [26].

2. Footwear: Inappropriate footwear, for example shoes with high or narrow heels, slip-on shoes and worn slippers, has been associated as a causative factor in up to 50% of falls [1].

Many intrinsic and extrinsic risk factors have been identified. Rubenstein (2006) pooled the risk factors and evaluated the most likely causes of falls in older adults. The most significant of these risk factors are muscle weakness as well as abnormal gait and balance. Gait, balance and weakness were found to be associated with 17% of falls, with a mean risk ratio of 3.0; 3.2 and 4.9 respectively [11]

Table 1: Causes of falls in older adults: A summary of 12 studies, which evaluated the most likely cause of falls in older adults [11].

Cause of fall	Mean Percentage [a] (%)	Range [b]
Accident/environment-related	31	1-53
Gait/balance disorders or weakness	17	4-39
Dizziness/vertigo	13	0-30
Drop attack	9	0-52
Confusion	5	0-14
Postural hypotension	3	0-24
Visual disorder	2	0-5
Syncope	0.3	0-3
Other specified causes [c]	15	2-29
Unknown	5	0-21

a Mean percentage calculated from 3628 falls in the 12 studies

b Ranges indicate the percentage reported in each of the 12 studies

c This classification includes arthritis, acute illness, drugs, alcohol, pain, epilepsy and falling from bed.

2.8 Assessing falls and fall risk

Measuring fall rates in older adults is a challenging exercise that requires long time frames and resources, making such studies costly. Therefore, most fall prevention programmes seem to initially focus on the assessment of fall risk; in order to identify those at highest risk so that targeted and specific interventions can be administered [79]. Fall risk assessments aim to assess functional limitations in gait and balance, and some tests have the ability to specifically predict falls probability [28, 80].

Fall risk assessments include the sitting functional reach test, where forward and lateral reach of an outstretched arm is measured, while sitting [81]; this test can be modified to measure standing forward and lateral reach [82], or multi-directional reach which includes backward leaning [83]. The step test has also been used to measure fall risk, as it incorporates dynamic single limb stance. This is a timed test to see how many steps can be completed in 15 seconds [84]. Furthermore, assessments that measure dynamic balance include the functional gait assessment [85] and the dynamic gait index and these tests both evaluate capability to adapt gait in response to varying task demand [86]. Lastly, the Tinetti Assessment Tool is a simple test that evaluates gait by examining factors like step length and symmetry, trunk movement and path deviation, while also assessing balance in chair standing to sitting ability, fall recovery after being gently nudged and ability to turn 360 degrees [87].

Despite the wide variety in fall risk assessments, the following tests were used in this study, due to the evidence for their predictability of falls. Beauchet et al., (2011) reported in a systematic review, that the timed up and go (TUG) test has been increasingly advocated as a tool to predict falls in older adults [88]. In addition,

another assessment tool that has been found to be useful is the BBS (Berg Balance Scale) [89]. This scale measures strength by assessing the performance of functional tasks among older people with impairment in balance function. Moreover, the five times sit to stand test (FTSST) has been shown to have a significant predictive value for recurrent falls; older adults who take more than 15 seconds to complete the test are at a 74% greater risk of falling than those who manage the test in less time [90].

In addition to these tests, the Biodex SD System (Biodex Shirley, NY), is also a well-used tool, and has been found to be reliable in assessing balance and fall risk in older adults [91], by providing stability and sway indices. Finally to add to these physical assessment tools, the Falls Efficacy Assessment- International (FES-I), which is a measure that quantifies fear of falling, was reported by Yardley et al., (2005). There is a strong correlation between fear of falling, and fall risk, balance and gait measures [58]. Therefore this assessment provides further insight into fall risk, and it also has the ability to predict future falls as well as decline in functional ability [92].

2.9 Benefits of physical activity in older adults

The process of ageing is complex, and involves many variables (e.g.: genetics, lifestyle factors, chronic diseases) that interact with each other, determining the manner in which we age [93]. Regular physical activity (aerobic and strength training) produces a number of favourable responses that contribute to healthy ageing [94]. Exercise has been shown to have positive effects on cognitive [95] and physical function [96] as well as postural stability [68].

Cardio vascular (CV) disease is a major cause of death in older adults, thus the effect of aerobic exercise on CV disease risk factors is of paramount importance. Several risk factors are decreased, and maximal aerobic capacity is increased as a result of regular aerobic exercise [97]. Older adults who regularly participate in endurance training benefit from lowered blood pressure; this effect is more pronounced in individuals with hypertension [98].

Furthermore, sarcopenia (the loss of muscle mass with age) is a major component of normal ageing that causes a reduction in muscle strength. There is some indication that actual muscle function decreases with ageing, but the majority of the loss in strength is caused from sarcopenia [99]. Between the ages of 50-70 years, it is generally found that there is a 30% reduction in strength (15% per decade), and from 70 years onwards, strength decreases by 30% each decade thereafter [100]. Therefore resistance exercise is important and one study has shown that through resistive exercise, older adults elicit similar or greater strength gains when compared to young adults [101].

In addition, the aged population often lack the ability to respond appropriately to disturbances in postural control, as their control strategy needs to be planned beforehand, unlike younger adults who demonstrate an automated feedback strategy which is more effective [102]. Therefore, improving postural stability through exercise is based on the fact that exercise enhances the overall system's response to balance and this leads directly to reduction of fall risk in older adults [100]. A recent study found that an exercise programme that focussed specifically on balance and stability was effective in improving postural stability and functional balance in older adults [103].

Lastly, ageing affects structures that make up joints, which may reduce the range and the function of joints. Improving flexibility enhances muscle or connective tissue properties, and this causes a reduction in joint pain and a change in muscle recruitment patterns. This contributes to improving individual's ability to perform activities of daily living [100].

2.10 Contraindications to exercise testing and training in older adults

Although exercise is beneficial in the ageing population, there are several conditions to consider in terms of weighing up the benefits versus the risks of exercise in older adults. Symptomatic and asymptomatic CV disease and contraindications precluding exercise are much more prevalent in older adults than in younger people. For this reason it is imperative to adhere to the following major absolute and relative contraindications set out by the ACSM [9]:

Table 2: ACSM contraindications to exercise testing and training in older adults [9].

Contraindications for exercise testing and training in older adults
• Recent ECG changes or myocardial infarction • Unstable angina • Uncontrolled arrhythmias • Third degree heart block • Acute congestive heart failure • Elevated blood pressure • Cardiomyopathies • Valvular heart disease • Complex ventricular ectopy • Uncontrolled metabolic disease

2.11 General exercise recommendations for physical activity in older adults

Even though no amount of physical activity can halt the biological ageing process, regular exercise can limit the development of chronic disease and disabling conditions, which will then allow for an increased active life expectancy [100]. All adults should avoid inactivity, and some exercise is better than none, with even small amounts of activity proving to be beneficial. Additional health benefits occur, with higher amounts of physical activity or higher intensity exercise [9]. Various guidelines emphasise that older adults should aim to achieve 150 minutes per week of moderate intensity aerobic exercise. If this is not achievable due to chronic conditions; older adults should be as physically active as their limitations allow [5, 101].

The current recommendations of the ACSM and AHA (American Heart Association) with respect to the frequency, intensity, duration and type of exercise and physical activity for older adults are summarised in table 3 [5].

Table 3: Summary of ACSM/AHA physical activity recommendations for older adults [5].

	Endurance	**Resistance**	**Flexibility**
Frequency	Moderate-intensity activities: Accumulate at least 30 or up to 60 (for greater benefit) min.d^{-1} in bouts of at least 10 min each to total 150–300 min.wk^{-1}. Vigorous-intensity activities: Accumulate at least 20–30 min.d^{-1} or more of vigorous-intensity activities to total 75–150 min.wk^{-1}, an equivalent combination of moderate and vigorous activity is advised.	At least 2 d.w^{-1}	At least 2 d.w^{-1}
Intensity	On a scale of 0 to 10 for level of physical exertion, 5 to 6 for moderate-intensity and 7 to 8 for vigorous intensity.	Between moderate-(5-6) and vigorous- (7–8) intensity on a scale of 0 to 10.	Moderate (5–6) intensity on a scale of 0 to 10.

Duration	Accumulate at least 30 min.d^{-1} of moderate intensity activity in bouts of at least 10 min each or at least 20min.d^{-1} of continuous activity for vigorous-intensity.		
Type	Any modality that does not impose excessive orthopaedic stress; walking is the most common type of activity. Aquatic exercise and stationary cycle exercise may be advantageous for those with limited tolerance for weight bearing activity.	Progressive weight training programme or weight bearing calisthenics (8–10 exercises involving the major muscle groups of 8–12 repetitions each), stair climbing, and other strengthening activities that use the major muscle groups.	Any activities that maintain or increase flexibility using sustained stretches for each major muscle group and static rather than ballistic movements.

2.12 Exercise interventions aimed at reducing fall risk

There are various interventions to reduce the risk of falls in older adults. For example, medication management (reducing the use of psychoactive medications, decreasing the use of medication such as tranquilisers, sleeping pills and anti-anxiety drugs), home modification (non-slip bath mats, hand rails and grab bars in bathroom and near stairs and improved lighting) and vision correction have all shown a reduction in fall risk [104]. However, most of the research has reported that exercise, as a single fall prevention intervention, is comparable to multifaceted interventions [105]. Therefore, although various interventions and multifactorial approaches have been successful in reducing fall risk and falls in older adults, exercise is specifically seen as a superior tool and the most crucial element in reducing risk and falls rates in this age group [20]. The one exception to this finding was reported by Campbell et

al., (2005) who found that home based exercise programmes were not as effective at reducing falls as home modification in older adults, however, the fact that these participants were visually impaired may have affected the outcomes of this particular study [106].

Despite considerable evidence supporting exercise in reducing fall risk, these programmes have not sufficiently been integrated into clinical practice [107]. There has been much debate over which exercise interventions, or elements thereof, are most successful for reducing fall risk and falls in older adults [18]. Understanding which factors within an exercise intervention are responsible for successfully decreasing fall risk and falls is essentially the cornerstone of fall prevention exercise interventions. Currently there is insufficient research available regarding optimal exercise prescription for the prevention of falls [108] and the duration of these programmes varies quite considerably [109]. ACSM/AHA guidelines currently acknowledge that those older adults who are frequent fallers, or those who have mobility problems, should participate in balance exercises. However, due to the lack of adequate research evidence, the ACSM at present has no specific protocol for exactly which exercises are the most effective for reducing fall risk and fall incidence.

Indeed, a systematic review by Sherrington et al., (2008), reported an overall reduction of 17% in fall rates with exercise, based on 40 trials and 9609 participants [17]. In addition to this, the meta regression analysis model revealed three pertinent facts that are linked with the efficacy of exercise training programmes namely; training dose, absence of a walking programme and balance training [17]. These topics are discussed in detail below:

2.12.1 Training dose and frequency

It is recommended that exercise interventions for fall prevention must be of a sufficient dose and frequency to have an effect and should run for at least 2 hours per week for a period of 6 months [105]. However, shorter exercise interventions, have also shown encouraging results. Improved balance was observed using exercise interventions that varied from as little as once per week for a period of 8 weeks [110] to once per two weeks for 6 months, accompanied by a home exercise routine [111]. Exercise programmes that are greater than 6 months are more likely to reduce the number and rate of falls [18]. Much of the research recommends that on-going exercise is necessary, and that the effects of exercise are rapidly lost; therefore in order for exercise to maintain a lasting fall prevention effect, it needs to be on-going [105]. Arnold et al., (2008) concluded that exercise once or twice per week, may be adequate in improving balance, functional ability and falls efficacy, but may not have a significant effect on muscle strength. Indeed it is still unclear whether exercise participation less than twice a week is suitable to improve all risk factors, and the optimal time spent per session is also vague [18].

2.12.2 Walking programmes

Strength and walking training may be included in conjunction with balance training, however high risk individuals, with more severe health-related risk factors, should not be prescribed brisk walking programmes [105]. This is in contrast with a systematic review by Howe et al., (2007) which included 34 studies with 2883 older adult participants, and reviewed a variety of exercise interventions [112]. Although they found balance and co-ordination, functional exercise, muscle strengthening and

multiple exercise types, to be the most effective interventions, they also recommended walking regardless of the participant's risk, as part of an effective fall prevention programme. In addition to this, a recent study concluded that walking among community-dwelling older adults can be more effective in the prevention of falls compared to balance training; however, walking should not be recommended to older adults who are susceptible to falling or frailty, as walking can induce tripping [113]. Therefore, there is contradicting evidence on the efficacy of walking as an intervention for reducing fall risk, and further studies are needed to expand on these guidelines. Furthermore, clearer conclusions are needed regarding the amount of walking that should be included into such exercise programmes, if any. In addition, guidelines regarding whether balance and co-ordination, and functional exercise should be prioritised over strength training within a fall prevention programme are also lacking.

2.12.3 Balance exercises

Finally, exercise interventions should deliver a moderate or high challenge to balance [105]. In addition to this, although the ACSM Exercise Prescription Guidelines have not included balance training into their official exercise recommendations for older adults, they do acknowledge the use of activities that include the following [5]:

- Increasingly difficult foot positions that progressively reduce the base of support; for example two-legged stand, semi tandem stand, tandem stand and single-leg stand.

 Semi tandem stand (one foot slightly ahead of the other)	 Tandem stand (one foot directly in front of the other)	 Single-leg stand

Figure 3: Foot positions to reduce base of support [5].

Dynamic movements that disturb the centre of gravity [105] (e.g., tandem walk, circle turns), exercise postural muscle groups (e.g., heel stands, toe stands) and reduce sensory input (e.g., standing with eyes closed) are important in exercise interventions [5]. Exercise should challenge balance by factors like: reducing the base of support and reducing the need for upper limb support while doing standing exercises [105]. Furthermore, non-specific group-based exercise interventions and individual lower-limb strength training are programmes that have been found to be less beneficial or needed further evidence for their efficacy [105]. From the literature, it appears that exercise programmes that address balance specifically are more beneficial than general exercise prescription; however this has yet to be proven.

Fall prevention exercise should be aimed at the general older adult community, in the form of a group class, as well as individual supervised exercise for those at high risk for falls [105]. Different groups will require different delivery strategies, for example those at higher risk will need closer supervision; either individual attention,

or a smaller group size [26]. Community-based group exercise programmes have been shown to improve balance, muscular strength and reaction time in older women [114]. In support of this, Chang (2004) established that there was limited evidence that individual exercise sessions are more effective than group classes for community-dwelling older adults, in terms of reducing the number of falls [13]. In addition Arnold et al., (2008) reviewed another 20 studies, and only three used individual exercise programmes; this research concluded that group, or individual exercise or a combination, can reduce the number of falls and the fall risk in older adults. Group classes, which are mainly used in randomised controlled trials, are advantageous for other reasons; the cost of delivering a group class is lower compared to a health-professional delivered exercise session, and the social networking is enhanced in group classes [18].

In addition to group and individual exercise, the availability of home based programmes is of particular importance, as many older adults are unable or reluctant to attend group classes or individual exercise sessions. A particularly well known home based programme; the Otago Exercise Programme, has been shown to lower fall rates and rate of injurious falls by 35% [16]. The programme involves five home visits by either a physiotherapist or a trained nurse, who would explain how the older adult needs to complete the exercise programme, followed by monthly follow up phone calls to the older adult, to encourage on going adherence [16].

Furthermore, Tai Chi exercise training has become a popular focus of recent research. Tai Chi is a traditional Chinese form of exercise that involves continuous, slow, flowing movements, body weight shifting, rotation of the trunk, head and

extremities, and this is combined with deep breathing and relaxation [115]. A Cochrane review explored evidence confirming the effect of Tai Chi for fall prevention, and concluded that evidence remained limited, and that Tai Chi is mainly effective in reducing falls in older adults who are at low risk of falling [25]. One study, with 200 participants determined that benefit from a Tai Chi intervention was probable, as the effects of Tai Chi on fall risk were estimated to decrease risk by 47% [116]. However only one randomised controlled trial on this intervention is available as yet, and even though the effect on fall reduction was significant, further trials are needed to support these effects [117]. Furthermore, a 10-week dynamic balance and stepping intervention was compared with Tai Chi training to improve balance and stepping in at-risk older adults, including 213 participants [20]. It found that dynamic balance and stepping improved outcomes more than Tai Chi training. The dynamic balance and stepping group saw improvement ranging from 9% for the TUG test, 5-10% for the maximum step length and rapid step test, and also greater static balance ability. Indeed, there appears to be limited evidence for the use of Tai Chi in reducing falls in the older adults [115].

Exercise providers should make referrals for other risk factors and chronic conditions to be addressed. For example, identifying and managing conditions like Parkinson's disease, stroke and arthritis could also reduce fall risk [2]. However, most studies have focused on healthy older adults, and further research is needed to elucidate whether older adults with chronic diseases can reduce falls and fall risk factors by participating in targeted exercise programmes [18].

Thus, it has been demonstrated in a large amount of research, including in a review of the research, that exercise interventions decrease the incidence of falls in older adults [25]. Even though some exercise interventions with components of balance and muscle strengthening showed a reduction in falls, it is not clear which elements or combination of elements are necessary to achieve this result [14]. There is also still uncertainty surrounding how long exercise interventions need to run for in order to decrease fall risk [18] and guidelines on the type and level of supervision necessary is also lacking [13]. Therefore, it is essential that research focuses on assessing specific elements of a fall risk intervention in order to identify the most efficient and effective exercise programmes that adequately address reducing fall risk and fall rates in older adults. This study aims to assess the effectiveness of two exercise programmes; a general exercise programme and a dynamic balance and stepping exercise programme, in terms of improving fall risk outcomes in older adults. The study will also compare the two programmes to each other, in order to determine whether one programme is more effective than the other. In addition the study will compare differences in fall risk outcomes in both groups between 8 weeks and 12 weeks of the intervention.

Chapter three

Methodology

3.1 Study design

The study used a prospective randomised experimental study design. Since the study was a randomised intervention, the CONSORT (Consolidated Standards of Reporting Trials) guidelines for reporting on randomised trials have been followed as much as possible [118]. The sample was randomly allocated into two groups, using random allocation software (Appendix C). Randomisation of groups was done in batches of twenty participants at a time. Graphpad QuickCalcs® Version 2014 (Graphpad Software, San Diego, California) was used; which first assigned each participant to a group non-randomly. Thereafter the software swapped each participant's assignment of group with a randomly chosen participant. This process was repeated twice to ensure accurate randomisation of participants. The process of allocating the participants to their randomised group occurred once participants were successfully enrolled in the study, but before the baseline assessment, and it was done according to which group their participant code was assigned to within the randomisation batch. The two groups were either: the general exercise group (GEG) or the dynamic balance and stepping exercise group (DBSG). Each group participated in one of these programmes for 12 weeks.

The independent variable in this research was the type of exercise intervention (either general exercise or dynamic balance and stepping programme). The dependant variables in this research was the outcome measures which indicate fall

risk. These measures were taken at 3 time frames; baseline, mid-intervention (8 weeks), and finally at post-intervention (12 weeks).

3.2 Study participants and recruitment

Participants over the age of 65 years were invited to participate in the study. Study participants were recruited through adverts that were placed in medical practitioners' rooms and retirement homes within a 20km radius of Melrose North, Johannesburg. Participants were included in the study if they met the inclusion criteria as detailed in table 4.

Table 4: Participant inclusion and exclusion criteria.

Inclusion Criteria	
• Aged 65 years and older	✓ An older adult is defined as being over 65 years [119]. Since this study focussed on fall risk within this population, participants aged 65 years and older were included in this study.
• Willingness to follow a 12 week exercise intervention	
Exclusion Criteria	
• Diagnosed pulmonary or cardiovascular signs and symptoms:	✓ In order to reduce the risk of a cardiac incident occurring during exercise participants were not included if they reported one or more of the following signs and symptoms: ✓ Pain, discomfort (or other angina equivalent) in the chest, neck, jaws, arms or other areas that may be due to myocardial ischemia (lack of adequate circulation) ✓ Shortness of breath at rest or with mild exertion ✓ Dizziness or syncope (fainting) ✓ Orthopnea (breathing discomfort when not in an upright position) or paroxysmal dypsnea (interrupted breathing at night) ✓ Ankle edema (swelling) ✓ Palpitations (abnormal rapid beating of the heart) or tachycardia (heart rate over 100 beats per minute) ✓ Intermittent claudication (cramping pain and weakness in legs, especially calves, during walking due to inadequate blood supply to muscles) ✓ Known heart murmur (atypical heart

	sound indicating a structural or functional abnormality) ✓ Unusual or unexplained fatigue.
• Uncorrected serious vision problems or vision loss	✓ Uncorrected vision problems or vision loss has a major effect on balance ability and capability to adapt to proprioceptive changes. Major vision impairments would interfere with the fall risk assessment, and exercise interventions. Including participants with uncorrected vision would put these individuals at increased risk of falling, and would affect their ability to make significant improvement gains in the post-intervention assessment.
• Vestibular problems	✓ Certain vestibular problems like dizziness and vertigo affect a person's ability to balance. These vestibular problems would interfere with the fall risk assessment, and exercise interventions. Including participants with these vestibular issues would put these individuals at increased risk of falling, and would affect their ability to make significant improvement gains in the post-intervention assessment.
• Major cognitive impairment	✓ Older adults who suffer from dementia and Alzheimer's or any other condition that may cause major cognitive impairment will battle to follow instructions within a class. This would affect the way that they participate in the exercise intervention.
• Serious illness or comorbidities that could affect the outcomes of the exercise interventions (e.g.: Parkinson's disease, terminal cancer, multiple sclerosis, end stage AIDS etc.)	✓ A participant that is diagnosed with an illness or disease may have limitation in full participation in the exercise classes.
• Major musculoskeletal injury causing an inability to carry out their activities of daily living	✓ A participant that suffers from major musculoskeletal injury may worsen their injury if they participate in the exercise classes.
• Total immobility	✓ A participant who is completely immobile and unable to achieve any ambulation would not be able to participate in a class environment, and thus be excluded from the study.
• Participation in a fall prevention exercise programme in the past 3 months	✓ In order to prevent participants having an unfair advantage due to familiarity of the exercises, recent participation in a fall prevention class would exclude participants from the study.

Forty five participants enquired about participating in the study; however four participants were excluded at recruitment phase. Exclusion was due to major cognitive impairment, and not being able to follow instructions (2 participants), which would influence their ability to participate in a group exercise class. One participant was not yet classified as an older adults, as she was under the age of 65 years, and finally one participant had partial blindness, which would affect his safety and ability to participate in a group class.

3.3 Study setting

The study setting was a private biokinetics practice, within a medical centre in Melrose North.

3.4 Participant drop outs (intention to treat)

Forty one participants were first enrolled in the study; 22% of the participants dropped out of the study, and all of these drop outs occurred in the first 8 weeks of the intervention. Following the intention to treat principle, all participants, regardless of compliance, have been reported on, however, analysis of the data was done on a per-protocol basis, due to the implication of missing data on the small sample size [12].

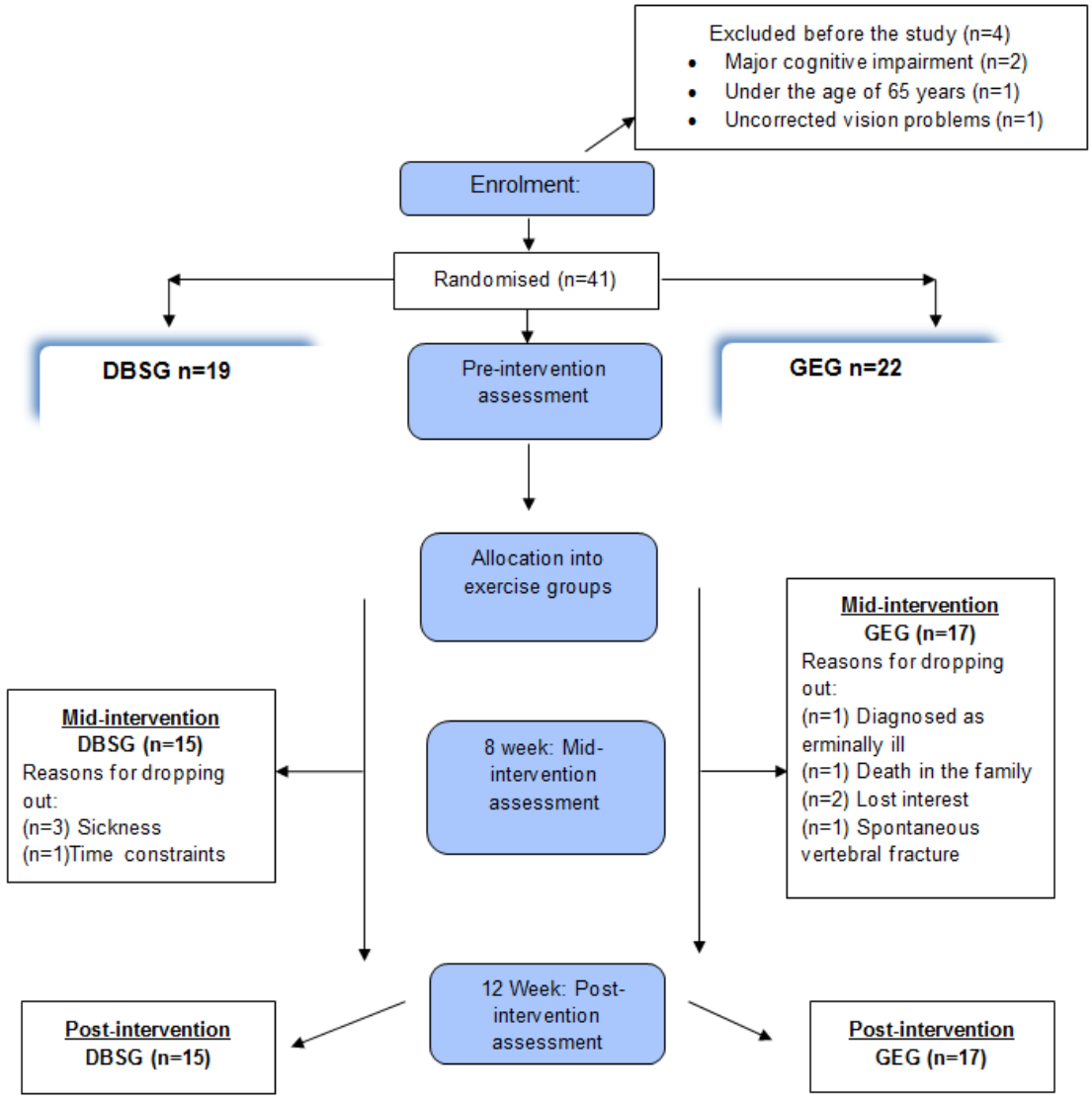

Figure 4: Consort flow diagram of study participants and intervention time lines.

3.5 Ethical considerations

An ethics application was submitted to the Human Research Ethics Committee (HREC) of the University of the Witwatersrand in April 2013. This application was approved unconditionally, and this certificate (M130446) is in Appendix D. Confidentiality of data is maintained at all times, and identification of the participants was removed for reporting purposes.

3.6 Assessment procedure

At the baseline assessment but prior to the commencement of the assessment each participant was given a participant information sheet (Appendix E). This document explained exactly what was expected from each participant throughout the duration of the study, including the fact that participation was voluntary. The participant information sheet also contained a consent form which notified the participants of any potential risks and benefits associated with participation in the study. Once the participants had read and agreed to participate, they were enrolled in the study. A brief medical history was administered by the researcher and was recorded in the form of a Physical Activity Readiness Questionnaire (PARQ). In addition, a medication list was compiled, recording each participant's prescription, and non-prescription medication; this was also facilitated by the researcher.

3.7 Data collection

Baseline and post-intervention (Appendix F) data was collected within 5 days before and after the start and end of the intervention. The protocol of testing and order of the post-intervention data collection was the same as that of the baseline data collection, and is detailed below. In addition, primary outcome data was collected at a mid-intervention time point within 5 days of the 8 week time point (Appendix F).

The protocol of testing at this time frame was also the same as the baseline data collection, except it excluded secondary outcome data. Secondary outcome data was collected at baseline and 12 weeks.

At the baseline assessment, once the participant information sheet, consent form, medical history (PARQ) and medication list were completed, the following data were recorded by the researcher, and measurements were taken according to the guidelines set out by the ACSM [9]. The order of the assessment is recorded below:

3.8 Baseline measures

3.8.1 Weight:

This was measured using a Safeway® electronic scale to the nearest 0.1kg; participant's shoes and heavy clothing, such as jackets, were removed.

3.8.2 Height:

This was measured using a Seca® stadiometer (SECA, Hamburg, Germany). Participants stood with their back against a wall where the stadiometer was mounted, with heels touching the wall. The head was kept in the Frankfort Horizontal Plane, and participants were asked to inhale, while the horizontal bar of the stadiometer was lowered to the top of the participant's head, height was recorded to the nearest 0.5cm.

3.8.3 Body Mass Index:

This was calculated by dividing the participant's weight in kilograms by their height in meters squared.

3.8.4 Supine Resting Heart Rate and Standing Heart Rate:

The participant rested for three minutes while lying on a plinth. The assessor palpated either the radial or the carotid pulse while the participant continued to lie on the plinth. The pulse was measured over 30 seconds and the figure was multiplied

by two, to get the beats per minute. The participant was asked to stand up as quickly as they could, and the assessor then immediately read the pulse in the same manner as done in the supine position.

3.8.5 Supine Resting Blood Pressure and Standing Resting Blood Pressure:

The participant rested for three minutes while lying down on a plinth. The assessor measured the blood pressure with a standard sphygmomanometer and stethoscope. The cuff was wrapped around the participant's upper arm at the level of the heart, and in line with the brachial artery. The stethoscope bell was placed below the antecubital space over the brachial artery. The cuff was inflated to 200mmHg, and then slowly released, at a pressure of 2mmHg/second. The first Korotkoff sound was noted (systolic blood pressure), pressure continued to be slowly released, and when the sound disappeared the diastolic blood pressure was be noted. The participant was asked to stand up, and the assessor immediately re-measured the blood pressure in the same manner as done in the supine position. The two blood pressures were compared to each other, and if there is a reduction of more than 20 mmHg in the systolic pressure and/or more than 10mmHg in the diastolic blood pressure, the participant will test positive for postural hypotension.

3.9 Primary outcome measures

3.9.1 The Five Times Sit to Stand Test (FTSST):

This is a measure of lower limb muscle functional strength [121]; it assesses how long it takes for an individual to stand up from a chair and return to a seated position, five times. This test has an interclass correlation coefficient of 0.95, and thus is considered a reliable test [121]. A cut-off score equal to or more than 12 seconds,

justifies the need for further assessment of fall risk [122]. Normal performance for the age group 60-69 years is equal to or less than a mean time of 11.45 seconds; for 70-79 years, 12.66 seconds and for 80-89 years, 12.7 seconds [123]. In addition, a score of more than 15 seconds indicates a high risk of recurrent falling [90]. The participant sat on a standard height chair (43-45cm), with his/her back against the back of the chair and arms crossed over chest. The participant was instructed to fully stand up and sit down again as quickly as possible, five times without the use of their hands. If any upper body assistance was needed, this was noted for standardisation of each test. Timing began with the instruction "GO" and ended when the participant's buttocks touched the chair on the fifth repetition [124].

3.9.2 Timed Up and Go Test (TUG):

This measure assesses mobility, as well as static and dynamic balance, and is valid and reliable with an excellent inter-rater coefficient of 0.99 and inter-rater reliability of 0.99 [125]. A cone was placed 3 meters away from a standard height chair (43-45cm) and participants were instructed to stand up from a chair without the use of their hands, walk three meters, turn around, walk back to the chair, and sit down, as quickly as possible. If any upper body assistance was needed, this was noted for standardisation of each test. Individuals were advised to wear their regular footwear and use a mobility aid if they usually used one. Timing began with the instruction "GO" and ended when the participant's buttocks touched the chair [126]. This test was repeated twice, and an average of the two readings was recorded.

3.9.3 Fall Efficacy Assessment-International (FES-I):

The falls efficacy assessment (Appendix G) was conducted on the participants to quantify their fear of falling, and the questionnaire was administered by the researcher. This scale is a valid and reliable measurement of fear of falling and its

test retest reliability (Pearson's correlation) is 0.71 [127]. The categories of concern are measured on a Likert-type scale from: not at all concerned, somewhat concerned, fairly concerned and very concerned, and a score from 1 to 4 is allocated for each question respectively. A composite score was calculated after the 16 questions were asked. From this, participants were categorised as low fear (score between 16 and 19), moderate fear (score between 20 and 27) or high fear (score between 28 and 64) in terms of their thoughts about falling [128,129]. Individuals were classified according to their risk.

3.9.4 Berg Balance Scale (BBS):

The BBS (Appendix H) is a measure of ability to maintain balance while completing functional tasks, and it is considered the gold standard of functional balance tests [130], therefore it is widely used in the geriatric population. A five-point scale ranging from "0-4" is used to objectively quantify the participant's balance, "0" indicates the lowest level of function and "4" the highest level of function, with a maximum of 56 for all 14 tasks [131]. The researcher described and demonstrated each task, and then observed and assessed the ability of each participant, giving them each one attempt to complete the tasks. It is a valid and reliable tool with inter-rater correlations of 0.97 [132]. Individuals were scored according to their performance during 14 physical tests, and classified according to their risk of falling. A score between 41- 56 is considered low fall risk (independent), a score between 21-40 is considered medium fall risk (walking aid needed) and a score between 0-20 is considered high fall risk (wheelchair bound) [133].

3.10 Secondary outcome measures

3.10.1 Biodex Overall Stability Test:

Balance is an important risk factor for falls, and can be described as the ability to maintain the centre of gravity of the body over the base of support [134]. The Biodex SD System (Biodex Shirley, NY), provides an overall stability index as a measure of balance, and this index has a good reliability, with an inter class correlation of 0.69 [135]. The multi axial device objectively measures ability to stabilise the involved joints under dynamic stress. The assessment consisted of 3 trials of 20 seconds (with a 10 second rest between trials). The participant stood comfortably in the centre of the circular board and foot position was noted using the grid that was printed on the board, this was done for standardisation of each test. There were handles on either side of the platform and participants were instructed to use them only if they needed support. At the beginning of each 20 second trial the platform started at level 12 (most stable), with 15 seconds remaining, the stability decreased to setting 11, at 12 seconds level 10, at 8 seconds level 9 and at 4 seconds until the test was completed the board was set at level 8 (least stable). As the stability of the board decreases, the board has the ability to move in the anterior-posterior axis and the medial-lateral axis simultaneously while the participant attempts to prevent the surface from moving by adjusting his/her balance [135].

3.10.2 Biodex Modified Clinical Test of Sensory Integration and Balance:

Sensory integration is defined as “the neurological process that organises sensation from one’s own body and from the environment and makes it possible to use the body effectively within the environment” [136]. This second measure of balance introduces additional sensory stimulation and the result is expressed as an overall sway index, and has a good reliability, with an inter class correlation of 0.81[164].

Once again, the participant stood comfortably in the centre of the circular board and foot position was noted using the grid that was printed on the board, this was done for standardisation of each test. There were handles on either side of the platform and participants were instructed to use them only if they needed support. The assessment consisted of four trials of 30 seconds each. Each trial tested one of four conditions namely: eyes open on a firm surface; eyes closed on a firm surface; eyes open on a foam surface and eyes closed on a foam surface. The platform remained stable for the entire test, and the participant's postural sway was measured relative to this stable platform. By manipulating the sensory conditions, participants were tested on their ability to integrate visual, vestibular and proprioceptive inputs during postural responses. This manipulation of sensory conditions, allowed for the quantification of relative reliance on various sensory inputs that were needed to maintain balance as well as their integration of this sensory information.



Figure 5: Biodex SD System (Biodex Shirley, NY) Biodex Medical Systems Inc.

3.11 Exercise interventions

The duration of both exercise interventions was 12 weeks, with two 1- hour group exercise sessions per week. Two qualified exercise professionals led the group classes, which were made up of a maximum of 6 people for safety and supervision reasons. Attendance rate of at least 70 % of the exercise was required to complete the study.

3.11.1 Dynamic Balance and Stepping Exercise Group (DBSG)

The DBSG completed an exercise programme that challenged dynamic balance, proprioceptive systems and stepping ability (Appendix I). The warm up consisted of a series of walking exercises that challenged gait patterns and stability.

Furthermore, various functional balance exercises and stepping routines were included. The programme also included functional ankle, knee and hip strengthening and was adapted from a balance and mobility training programme described by Rose and research by Nodium et al. [20, 137]. Progression was done on an individual basis and accordingly to proficiency of a task, this was based on rate of perceived exertion according to the modified Borg scale (Appendix J). If participants reported a rate of perceived exertion below 6 out of 10, the exercise was adjusted by increasing their stepping height, adding foam mats to their balance exercises and increasing the complexity and length of the obstacle course.

3.11.2 General Exercise Group (GEG)

The ASCM has published a position stand as an overview to understanding the importance of exercise in older adults [5]. The guideline makes reference to frequency, intensity and mode of exercise, and each of these is applied to the three types of exercise namely endurance, resistance and flexibility. Therefore the GEG completed a moderate intensity (rate of perceived exertion between 5 and 6 out of 10) exercise programme that was based on these guidelines. The 15 minute warm up consisted of a variation of three of the following modes of exercise: treadmill walking, rowing, stationery cycling or arm cycling. Participants then were taught how to stretch their main muscle groups in a seated or standing position (triceps deltoid, gluteus, hamstring, calf, and quadriceps); assistance was provided where necessary. The resistance element of the programme was a series of exercises that were performed seated, standing and in a supine position. This was followed by a cool down that included shoulder rolls and gentle neck stretches (Appendix K) [5]. If participants reported a rate of perceived exertion below 5 out of 10, the exercise was

adjusted by increasing the arm and ankle weights, as well as increasing the number of repetitions performed.

3.12 Sample size calculation

Sample size was calculated using a confidence interval of 95%, statistical significance was set at 0.05 and expected difference between groups was estimated at 10% [20]. It was assumed that the drop-out rate would be 20%. Therefore, a target sample size of 174 people was set, to manage with participant drop outs and attrition (Appendix L). However due to poor response, financial reasons and feasibility, the end sample size was much smaller than originally planned.

3.13 Statistical analysis

Baseline data of the group characteristics was collected prior to the intervention and this was compared to the mid-intervention data, as well as data collected at trial completion. Statistica® version 12 (StatSoft, Inc., Tulsa, Oklahoma, USA) was used to analyse the data. Shapiro-Wilk tests were done to test for normality distribution of the data. For normally distributed data, mean and standard deviation are provided and the t-test was used to calculate significant differences between the two groups and between two time points (baseline and 12 weeks). For non-normally distributed data, median and range is discussed and the Mann-Whitney test was used to calculate significant differences, between the two groups and between two time points (baseline and 12 weeks). When clinically relevant, the mean and SD may be described. Data was log transformed and multifactorial Analysis of variance (ANOVA) tests were used to analyse the data between the three time points. Further analysis of the Anova was done using a Scheffe's post hoc test. The significance adapted to all analyses was ≤0.05.

Chapter four

Results

4.1 Sample baseline demographics

Thirty two participants (N=32), with a mean age of 80±7 years, were randomly assigned to one of two exercise intervention groups. Participants were allocated to either the DBSG (n=15, mean age 78.±7 years) or the GEG (n=17, mean age 82.±7 years) and attended one hour group classes twice a week. Attendance was affected by sickness, occasional lack of transport and/or prior arrangements; however, participants from both groups attended on average 20 of the 24 exercise sessions (85%).

Group descriptive statistics of the baseline outcome variables (N=32) is shown in Table 5. The group as a whole appeared to be at risk of falling in many of the variables. For example, functional strength (FTSST=15.21±4.57s) demonstrated the sample was at risk of falling, and fear of falling (FES-I=27.94±9.11) indicated moderate to high fear of falling. However, the group had a mean score of 47.16 (±7.33) out of a possible 56, for the BBS, indicting low fall risk and a mean score of 11.78±6.55s for the TUG also indicating low risk of falling.

Table 5: Baseline outcome variables for the sample (N=32).

Outcome variables	Mean (±SD)
Five times sit to stand (seconds)	15.21±4.57
Timed up and go (seconds)	11.78±6.55
Fear of falling score	27.94±9.11
Berg balance score	47.16±7.33
Biodex overall stability index	1.14±0.62
Biodex sway index (eyes open, firm surface)	0.84±0.36
Biodex sway index (eyes closed, firm surface)	1.75±0.82
Biodex sway index (eyes open, foam surface)	1.39±0.54
Biodex sway index (eyes closed, foam surface)	4.29±1.12

Baseline comparisons were made on resting measurements (Table 6) and outcome variables (Table 7). No statistically significant differences were found between the groups at the baseline. This suggests that the groups were homogeneous, and that any changes in outcome measures between the groups can be assumed to be due to the exercise intervention.

Table 6: A comparison of the participants' baseline descriptive variables for the DBSG and the GEG.

Resting variables	DBSG (n= 15) Mean (±SD)/ Median (range)	GEG (n=17) Mean (±SD)/ Median (range)	P value
Male to female ratio	5:10	8:9	
Gender (%) Male Female	 33 67	 47 53	
Age (years)	78 (±7)	82 (±7)	0.13
BMI (kg/m2)	24.34 (22.48-45.42)	25.99 (14.59-41.12)	0.79
Supine resting heart rate (bpm)	70.00 (58.00-88.00)	66.00 (54.00-88.00)	0.41
Supine resting systolic blood pressure (mmHg)	130.00 (100.00-190.00)	132.00 (102.00-170.00)	0.44
Supine resting diastolic blood pressure (mmHg)	62.00 (40.00-80.00)	78.00 (50.00-94.00)	0.17

Table 7: A comparison of the DBSG and GEG baseline outcome variables.

Outcome variables	DBSG (n= 15) Median (range)	GEG (n=17) Median (range)	P value
Five times sit to stand (seconds)	13.91 (8.66-22.03)	17.59 (8.53-24.78)	0.08
Timed up and go (seconds)	10.13 (6.05-18.61)	11.03 (6.54-42.11)	0.31
Fear of falling score	29.00 (15.00-42.00)	26.00 (15.00- 54.00)	0.47
Berg balance score	49.00 (40.00-56.00)	48.00 (28.00-56.00)	0.31
Biodex overall stability index	1.10 (0.40-3.10)	1.00 (0.30-3.30)	0.85
Biodex sway index (eyes open, firm surface)	0.80 (0.33-1.99)	0.80 (0.41-1.30)	0.94
Biodex sway index (eyes closed, firm surface)	1.62 (0.66-4.39)	1.61 (0.66-3.03)	0.96
Biodex sway index (eyes open, foam surface)	1.37 (0.83-2.30)	1.14 (0.73-3.17)	0.72
Biodex sway index (eyes closed, foam surface)	4.36 (2.51-6.49)	4.60 (1.44-5.63)	0.78

4.2. Changes over time: Intra group comparisons.

4.2.1. Functional strength

Scores for functional strength outcomes are shown in Table 8. Over the 12 week intervention, the mean FTSST score for the DBSG improved from 13.78 (±3.84) seconds at baseline to 12.31 (±2.32) seconds at post-intervention, and using repeated measures ANOVA, this change over time was statistically significant (p= 0.01). Scheffe's post hoc test showed a significant change over time for this group between the mid-intervention (15.71±4.12) and the post-intervention (12.31±2.32), and these differences in scores were statistically significant (p= 0.02).

Although the mean FTSST score for the GEG improved from 16.48 (±4.90) seconds at baseline, to 15.22 (±3.56) seconds post-intervention, this change in the score was not statistically significant. Post hoc analysis also showed no statistically significant changes in time for the FTSST scores at each time point for this group.

ANOVA analysis showed no statistically significant differences between the two interventions groups for this outcome variable. However, the difference between the two groups, at 12 weeks, was 2.91 seconds (with the DBSG performing better than the GEG) and according to Goldberg et al., (2012) a change that exceeds 2.50 seconds should be considered real change beyond measurement error [121]. Therefore we can assume that from a clinical perspective there was a difference between the two groups at post-intervention, even though statistically there was no difference between the groups.

4.2.2. Functional balance

Scores for functional balance outcomes are shown in Table 8. The baseline mean BBS score for the DBSG was 49.00 (±5.41), out of a possible 56.00 (low fall risk). After the intervention this group's score remained in the low fall risk category, and

showed a statistically significant overall effect over time (p= 0.01). Even though the repeated measures ANOVA found a significant change over time, the post hoc test only showed a potential for change between baseline and 12 weeks, and this change was not statistically significant (p= 0.07), possibly due to the study being underpowered.

The baseline mean BBS score for the GEG was 45.53 (±8.51), (low fall risk), and although this score tended to improve to 47.59 (±7.12), remaining in the low fall risk category after the intervention, and the change in score was not statistically significant (p= 0.64).

The ANOVA showed a statistically significant difference between the two groups (p= 0.01). This difference was observed, with the DBSG (53.73±1.91) performing better than the GEG (47.59±7.12), p= 0.04 at the 12 week time point.

Although not statistically significant the difference in scores between baseline and post-intervention in the DBSG was 4.73 points. According to Donoghue et al., 2009, the minimal detectable change for scores between 45 and 56 is 4 points. Therefore, although the difference in the between group scores at this time point was not statistically significant, there was sufficient change in the score to deem a clinically significant improvement.

4.2.3. Mobility

The GEG showed statistically significant improvements in the time taken to stand up from a chair, walk three meters, turn around, walk back and then return to the same seated position, over the 12-week intervention (Table 8). The mean time in seconds at baseline was 12.95 (±8.28), and at post-intervention the mean time was 10.89 (±4.22) seconds; p= 0.01. Post hoc analysis showed these changes occurred

between the mid and post-intervention assessment, where differences were considered statistically significant (p= 0.04).

In the DBSG, there were no statistical differences in mean time taken for this group to complete the TUG test. Although the DBSG improved from a baseline time of 10.44 (±3.59) to 8.98 (±2.09) seconds post intervention, the ANOVA showed no statistical significant difference in this outcome.

4.2.4. Fear of falling

The baseline mean fear of falling score for the DBSG was 28.93 (±8.57), which categorised this group as having a borderline high fear of falling, after the intervention the score tended to reduce to a score of 23.67 (±4.98), categorising them as having moderate fear after the intervention. This change however was not considered statistically significant.

The mean fear of falling score for the GEG at baseline was 27.06 (±9.74), placing this group in a category of moderate fear. Although the GEG score increased somewhat to 27.94 (±11.33), at the post-intervention assessment, the category of fear remained unchanged (moderate), and the change in fear was also not considered statistically significant.

At both the mid-and post-intervention assessment, the fear of falling scores for the DBSG were lower than those achieved by the GEG, however between group comparisons were not statistically significant. These scores are represented in Table 8.

Table 8: Mean scores at Baseline, 8 and 12 weeks for the DBSG and the GEG.

Outcome measures	Group	Baseline	Mid-intervention	Post-intervention	P value	P value
	DBSG n=15 GEG n=17	Mean (± SD)	Mean (± SD)	Mean (± SD)	Within group	Between groups
FTSST	DBSG	13.78±3.84	15.71±4.12	12.31±2.32*	0.01	0.11
	GEG	16.48±4.90	16.60±4.81	15.22±3.56		
BBS	DBSG	49.00±5.41	52.47±3.23	53.73±1.91†	0.01	0.01
	GEG	45.53±8.51	45.41±7.86	47.59±7.12		
TUG	DBSG	10.44±3.59	10.31±2.50	8.98±2.09	0.01	0.20
	GEG	12.95±8.28	12.78±5.16	10.89±4.22‡		
FES-I	DBSG	28.93±8.57	25.60±6.92	23.67±4.98	0.12	0.64
	GEG	27.06±9.74	29.47±11.12	27.94±11.33		

* P=0.02 (within group difference 8-12 weeks) †P=0.04 (between group differences at 12 weeks) ‡P=0.04 (within group difference 8-12 weeks)

4.2.5. Postural sway

The Biodex overall stability and sway indexes for both groups are reported in Table 9. The DBSG median baseline Biodex overall stability index was 1.10 (0.40-3.10), while median post-intervention Biodex overall stability index was 1.00 (0.20-2.20). The GEG median baseline Biodex overall stability index was 1.00 (0.30-3.30), and the median post-intervention Biodex overall stability index was 1.00 (0.40-2.50). No statistically significant differences between medians were observed in both groups after the exercise interventions, p= 0.23 (DBSG) and p= 0.70 (GEG).

In the DBSG, one of the four Biodex sway indexes in the modified clinical test of sensory integration and balance improved after the intervention. The improvement was observed while participants had their eyes open and stood on a foam surface. This change was statistically significant as the index improved from a baseline score of 1.37 (0.83-2.30) to a post-intervention score of 1.17 (0.66-1.95); p= 0.02.

Conversely in the GEG, one of the four Biodex sway indexes in the modified clinical test of sensory integration and balance worsened after the intervention. Statistically significant differences were observed while participant's had their eyes open and stood on a foam surface; the sway index regressed from a baseline mean score of 1.14 (0.73-3.17) to a post-intervention score of 1.37 (0.88-3.84) p= 0.05.

At post-intervention, no between group differences were observed in postural sway medians. The overall stability index for the DBSG was 1.00 (0.20-2.20) and similarly overall stability index for the GEG was 1.00 (0.40-2.50), p= 0.99. Although the Biodex Stability index scores for the DBSG were lower than the GEG, except for one condition, (eyes closed, foam surface); none of these differences were considered statistically significant. These scores are represented in Table 10.

Table 9: Postural sway outcomes baseline, mid-intervention and post-intervention for the DBSG and GEG.

Outcome measures	DBSG (n= 15)			GEG (n=17)		
	Baseline Median (range)	Post-intervention Median (range)	P value	Baseline Median (range)	Post -intervention Median (range)	P value
Biodex overall stability index	1.10 (0.40-3.10)	1.00 (0.20-2.20)	0.23	1.00 (0.30-3.30)	1.00 (0.40-2.50)	0.70
Biodex Sway Index (eyes open, firm surface)	0.80 (0.33-1.99)	0.78 (0.41-1.37)	0.87	0.80 (0.41-1.30)	0.86 (0.45-2.88)	0.76
Biodex Sway Index (eyes closed, firm surface)	1.62 (0.66-4.39)	1.45 (0.66-3.39)	0.40	1.61 (0.66-3.03)	1.82 (0.73-3.66)	0.07
Biodex Sway Index (eyes open, foam surface)	1.37 (0.83-2.30)	1.17 (0.66-1.95)	0.02*	1.14 (0.73-3.17)	1.37 (0.88-3.84)	0.05*
Biodex Sway Index (eyes closed, foam surface)	4.36 (2.51-6.49)	3.69 (2.88-5.48)	0.11	4.60 (1.44-5.63)	3.99 (2.12-5.97)	0.50

** P≤0.05*

Table 10: Between group comparisons of Biodex stability indexes post-intervention.

Outcome measures	DBSG (n=15)	GEG (n=17)	P value
	Post-intervention Median (range)	Post-intervention Median (range)	
Biodex Overall Stability index	1.00 (0.20-2.20)	1.00 (0.40-2.50)	0.99
Biodex Stability Index (eyes open, firm surface)	0.78 (0.41-1.37)	0.86 (0.45-2.88)	0.91
Biodex Stability Index (eyes closed, firm surface)	1.45 (0.66-3.39)	1.82 (0.73-3.66)	0.11
Biodex Stability Index (eyes open, foam surface)	1.17 (0.66-1.95)	1.37 (0.88-3.84)	0.09
Biodex Stability Index (eyes closed, foam surface)	3.69 (2.88-5.48)	3.99 (2.12-5.97)	0.72

** P≤0.05*

In summary, statistically significant improvements were observed in the functional strength outcome, the FTSST, for the DBSG, these changes occurred between the mid and post-intervention (p= 0.02). No differences occurred in the FTSST for the GEG group over the 12 weeks. Although between group comparisons for this outcome variable showed no statistical difference, the difference between the two groups at post-intervention does exceed the minimal detectable change value and therefore we can assume from a clinical perspective, the DBSG performed better than the GEG.

Scores for functional balance showed a similar trend, with the DBSG significantly improving over time; p= 0.01. Differences between the two groups where found with the DBSG performing better than the GEG for the BBS score at the post-intervention assessment (p= 0.04).

Furthermore, statistically significant improvements in the TUG score were specifically noted in the GEG group between the mid and post-intervention p= 0.04.

No differences in fear of falling was observed for either group over time, or when comparing the two groups.

Finally the sway index with participants standing on a foam surface with their eyes open showed a statistically significant improvement for the DBSG (p= 0.02); however the GEG stability index for the same condition worsened, and this result was also statistically significant (p= 0.05).

Chapter five

Discussion

5.1 The concept of exercise prescription

Exercise prescription refers to a specific plan of exercise-related activities that are designed for a particular purpose, and generally it is composed of four components: frequency, intensity, mode and duration [9]. Frequency refers to the number of days per week devoted to an exercise session; intensity refers to how hard an individual will work to do the exercise activity, the mode is the type of exercise and finally the duration denotes how long the exercise sessions will be performed, in weeks or months [138].

Exercise prescription is specifically important in the ageing population, and the World Health Organisation has recommended an active lifestyle as a solution to ensuring that health and well-being is maintained in later life [94]. Although much of the literature states that exercise is one of the most effective interventions in the prevention of falls in older adults, there is still debate surrounding which combination of exercises are the most effective in reaching the intervention goals [14, 108, 139].

This study compared the effectiveness of two different modes of exercise, over a period of 8 and 12 weeks. These differences were expressed in terms of the following fall risk outcomes; functional strength and balance, mobility, fear of falling and postural sway. The results indicate that a dynamic balance and stepping exercise programme is effective in terms of improving functional strength and balance outcomes in older adults, and is specifically more effective than general exercise for the improvement of functional balance outcomes. In addition, a dynamic balance and stepping programme causes improvements in sway indexes in the modified clinical test of sensory integration and balance. On the

other hand, a general exercise programme has a positive effect on mobility outcomes for this age group, but a negative effect on sway indexes in the modified clinical test of sensory integration and balance. Fear of falling is not affected by either of these two exercise programmes.

5.2 Exercise interventions

The DBSG took part in an exercise programme that worked on dynamic balance, proprioception, visual and vestibular systems as well as stepping ability and it consisted of exercises that involved stability training and routines that challenged various gait patterns. The GEG participated in a general exercise programme according to the ACSM guidelines for older adults. The programme consisted of cardiovascular training, flexibility, as well as resistance training of the major muscles groups, and did not purposefully focus on balance training. The results from this study demonstrate that interventions that are made up of exercises that challenge dynamic balance and practice stepping ability are effective in decreasing certain fall risk outcomes in older adults. Although general exercise also shows favourable improvements in specifically the TUG, balance and stepping exercises seem to result in more of an overall risk improvement. Balance is a task-specific skill and this may explain why including balance type activities seems to improve balance purposefully, as seen in this study.

5.3 Functional strength and balance outcomes

5.3.1 FTSST

The FTSST has been reported to measure many fall risk outcomes, such as; lower limb muscle functional strength [121] postural control [145], fall risk [54, 63]; proprioception [145] and disability [147, 148]. Older adults with underlying balance disorders take longer to complete

the FTSST than those without balance impairments [124]. Slower sit-to-stand scores have been useful in anticipating future disability [148, 149].

In the current study, the DBSG reduced their mean time to almost less than 12 seconds post-intervention. This is clinically important, because there is a 12 second cut off that is used for the FTSST [123]; scores equal to or less than 12 seconds indicate normal time taken. On average, participants in the DBSG achieved a normal time for the FTSST, after the intervention, and as a result this group was less likely to fall due to intervention. The improvement in scores noted in the current study, are similar to the change in scores in a study by Piva et al., (2010), where participants were given a functional training exercise programme that included balance exercises. The study involved 6 weeks (12 sessions) of a supervised exercise programme, followed by a 4-month home exercise programme. The participant's scores decreased, (therefore improving their time to complete the FTSST) between baseline and the 2 month follow, up by 3.4 seconds. From baseline to the 6 month follow up, where participants had continued with a home programme, their scores also decreased by a total of 4.6 seconds [150].

The implications of improving sit-to-stand ability, apart from directly decreasing fall risk, is that in older adults this has an effect on simple yet vital day to day tasks. Sit-to-stand movement evaluates the ability to perform transitional movements [124], the ability to perform activities of daily living [151] and also the level of independence of older adults [54, 63].

Possible reasons why the DBSG showed better results than the GEG for the FTSST are that the dynamic balance and stepping intervention challenged skills that are fundamental to proprioceptive control, centre of gravity awareness and the ability to control changes in one's centre of gravity; all of these skills are vital in the sit-to-stand ability. This perhaps explains why the GEG did not improve in this outcome measure. Although general leg

strength would be expected to improve, after a general exercise programme, the sit-to-stand movement requires more of a functional leg strength that includes, postural sway control and centre of gravity awareness, and this was not addressed in the GEG. Shamay (2010) drew similar conclusions when describing the sit-to-stand movement as a movement requiring not only lower body strength, but also muscle endurance and proficient postural responses to changes in position. He confirmed the importance of balance skill rather than muscle strength and exercise endurance as an important factor of performance in the FTSST [152]. Consequently, dynamic balance and stepping exercises seem to be more effective in improving functional strength in the form of chair rises. Due to the fact that rising from a chair is a movement that is usually performed several times a day for most individuals, these kinds of dynamic balance and stepping exercises should be accentuated in exercise programmes for older adults, and specifically if fall risk outcomes need improvement.

Interestingly, although an overall improvement in functional strength occurred over the 12 week intervention in the DBSG, these outcomes initially regressed between baseline and the mid-intervention assessment. Even though this change was not statistically significant, it suggests that changes in functional strength and skill precision involved in the sit-to-stand movement need at least 12 weeks to display proficiency in these learnt movements.

5.3.2 BBS

A systematic review, comprising of three trials that consisted of 356 participants, found statistically significant improvements in the BBS scores (1.7 points) in participants who did general exercise that included balance, when compared to the control group that just did sham or light intensity exercises [153]. Indeed, the current study also showed statistically significant improvement in BBS scores, specifically for the DBSG with the score improving by 4.73 points between pre and post-intervention assessments. Although the GEG score did change by 1.96 points between pre and post-intervention assessments, the difference

in scores was not statistically significant. The current study reported a greater improvement in the BBS scores of the DBSG, who focussed primarily on dynamic balance and stepping exercises, compared to the systematic review that included only some balance exercises in addition to general exercises. This suggests that a greater change in BBS scores occurs when the type of the exercise programme is primarily dynamic balance and stepping, compared to exercise programmes where only some balance exercises are prescribed, but the bulk of the exercises is general exercises.

This is consistent with results from a meta-analysis by Sherrington et al., (2008) that reported that moderate to high challenging balance training was the only type of exercise to statistically significantly have a protective effect on rates of falls (17% reduction in fall rates). Other types of exercise, such as strength training, stretching or walking, did not have a statistically significant protective effect on fall rates [17]. Even though in the current study differed somewhat and the GEG did show significant improvements in other fall risk outcomes, the DBSG displayed more change in functional strength and balance outcomes. On the basis of this, balance training seems to be the most effective intervention in improving balance and reducing falls, and exercises performed in a standing position with minimal upper body support are ideal.

5.4 Mobility outcomes

Statistically significant improvements occurred in the TUG score for the GEG and not in the DBSG. This may indicate that general exercise is more effective than balance and stepping exercises for improving mobility outcomes in the elderly. A possible reason for the improvement in mobility is that treadmill walking was practised during the warm up for the GEG. Even though other skills that are needed in TUG test like changing direction or turning around a cone, were not practised, practicing walking skill alone could have contributed to the general ambulation ability, and therefore the mobility outcome measure

for this group. In addition, general lower body strength exercises as performed by the GEG would have also contributed to this group's improvement in mobility. Therefore since the GEG showed improvements in strength and fitness, there were able to walk faster, as seen in the TUG score improvement.

In contrast to this, Cardoso and Alfieri (2011) and Alfieri et al., (2010) showed that mobility can be significantly improved using an exercise programme that emphasised proprioceptive stimulus, as opposed to a general exercise programme, as seen in the current study [155, 156].

A previous study discussed an exercise programme that focussed on postural control exercise as an intervention to improve mobility in older adults. This study showed that participant's TUG score did not significantly improve after the 8 week exercise intervention (one hour, bi-weekly sessions). The mean time at baseline was 17.92 seconds, and at post-intervention the time was 16.35 seconds, which still represented a high risk for falling. The researchers attributed the lack of change in the results to factors such as; the time of the intervention, characteristics of the sample, as many participants had associated diseases or the type of stimulus within the exercise programme [154].

In the current study, intragroup comparisons indicated similar results, whereby the GEG did not improve in their TUG score by the 8 week assessment, but only after the full 12 week intervention, did scores significantly improve. This indicates that the length of the exercise interventions should be longer than 8 weeks in order for mobility outcomes to improve.

This study shows that mobility, which is an important fall risk outcome, can be improved in older adults who are at risk of falling. However, as seen in the current study, there is an intricate relationship between the type of exercise performed and the length of the exercise

intervention on mobility performance. In addition, these factors will influence an individual's mobility relative to their initial mobility as well as their general health.

5.5 Fear of falling outcomes

Balance training can lead to a reduction in fear of falling for older adults [157]. However some research has found that combining exercise and education is more effective because fear of falling is affected not only by physical problems but also by cognitive and psychological issues [158]. In the current study, neither of the exercise interventions was effective in improving fear of falling in the participants, and perhaps this is due to the cognitive and psychological issues around fear of falling not being addressed in the form of an education programme.

Furthermore Madureira et al., (2010), described how reducing fear of falling after a balance training intervention led to an improved quality of life in older adults [159]. This may be attributed to the fact that balance training may directly reduce the decline in physical functioning and mobility [157]. It teaches individuals how to adjust centre of gravity, weight bearing control, change positions and maintain stability, and this may lead to a decrease in their fear as they had learnt ways of re-gaining balance and maintaining stability. In addition however, fear of falling in older adults, increases with age [48].

In addition to this, however, a meta-analysis by Dukyoo et al., (2009) grouped studies according to the duration of follow up; either three months or less or 4 months or more. When assessing the effectiveness of reducing fear of falling; it was found that significant results were observed for interventions that were assessed fear of falling after 4 months [158]. This suggests that interventions for reducing fear of falling may not be immediately successful, but results would rather be seen after some time [158]. This perhaps explains

why no differences were observed in the current study, it seems that exercise programmes need to be longer than 12 weeks in order to see positive results.

5.6 Postural sway

After the intervention, the DBSG showed significantly less sway on the foam surface with eyes open compared to baseline. This suggests that although the participants found it difficult to integrate visual information while somatosensory information was distorted, after the intervention, sensory integration was improved. The DBSG exercise programme relied on sensory and reactive movement strategies while standing on the foam pad, and this seems to have improved standing postural control in these participants.

In the GEG however, scores significantly worsened after the intervention while on the foam surface with eyes open. The exercise programme that the GEG took part in did not include any exercises on the foam pad. This is perhaps why these participants had not been able to train their sensory and reactive movement strategies, and this may be one of the reasons for postural control worsening over time.

From this study, it appears that individuals who participate in exercise programmes in the hope of improving their balance, but who don't actually partake in a mode of exercise that addresses the sensory component of postural sway, may actually increase their postural sway. Physical gains achieved through these types of exercise programmes may be enough to improve the individual's mobility but not enough to attain a protective effect if the individual's increased activity level exceeds their balance ability [160]. It was noted that one of the outcome measures for postural sway using the biodex balance tool displayed statistically significantly worsened scores for the GEG at post-intervention. Scores for the stability index with eyes open and on a foam surface, increased from 1.36±0.59 to 1.58±0.74. These results indicate a decrease in stability, and an increased fall risk. These

findings are similar to the results discussed by Lord in 2003, where postural sway ability worsened after a 12 month bi-weekly exercise intervention. This exercise programme included balance, gait and co-ordination activities, as well as strength and functional tasks such as balancing while turning and reaching, rising from a chair, negotiating stairs. The changes that occurred in his study took place in all four of the sensory conditions, namely eyes closed and on a firm surface; eyes open and on a foam surface; as well as eyes open, on a firm surface and eyes closed on a foam surface. The author attributed this worsening in sway to age-related changes over the 12 month intervention. Even though the current study was only 12 weeks long, it may suggest that age-related changes in at risk older adults can occur within this time frame. Future studies however would need to confirm this.

5.8 Length of exercise interventions

Research has shown that exercise programmes that involve a higher dose of exercise, have greater effects on reducing falls [17]. A meta-analysis compared studies that had prescribed a total exercise dose of 50 hours (2 hours per week for a period of 6 months), and found a 23% reduction in falls for interventions more than 50 hours long, compared to a reduction of falls of 7% for interventions less than 50 hours long [105]. However, other studies do not provide a clear cut-off and indicate that there are superior benefits from higher doses of exercises [144].

The current study compared fall risk outcomes at baseline, 8 weeks (16 hours of exercise intervention) and at 12 weeks (24 hours of exercise intervention). Where differences were noted, these were only true between 8 and 12 weeks. When looking at the FTSST outcome variable, DBSG scores between the baseline and the mid-intervention assessment tended to worsen slightly however a significant improvement then occurred between the 8 and 12 week time point. Similarly the significant differences occurred for

the TUG test, but for the GEG, and this change also occurred specifically between the 8 and 12 week time point. In fact, within both groups, no statistically significant differences were observed between the baseline and 8 week time frame.

This could suggest that the improvement in scores had not yet plateaued at the 12 week time frame, and may in fact continue to improve if the intervention was longer than 12 weeks. This suggests that a minimum of 12 weeks is needed to observe differences in fall risk for both the dynamic balance and stepping exercise programmes, as well as the general exercise interventions. Follow up data and a longer intervention period would be needed to confirm this.

Even though fall risk outcomes in the current 12 week study have shown statistically significant improvements, other studies have found that long term (≥ 3 years) participation in exercise for preventing falls tends to lower the incidence of falls, compared to short-term (1-2 years) exercise programmes [162]. Further research is needed to delineate what the minimum duration of exercise programmes should be in order to have a significant effect on reducing fall risk, but perhaps more importantly fall incidence. However, the current study indicates that 12 weeks (24 sessions) is superior to 8 weeks in terms of decreasing fall risk outcomes in older adults.

5.9 Study limitations and recommendations

Future research could overcome some of the limitations of this study by using a larger sample size. The target sample size was calculated as 174 people, however in the end, the study only had 32 participants. Although the between group differences in scores at the mid-intervention assessment and the post-intervention assessment for the FES-I, were not statistically significant, the trend indicated that the DBSG had less concern for falling at both time points. Similarly at the post-intervention assessment, the Biodex stability index

scores for the DBSG tended to be better than the GEG scores for all four sensory conditions, however the difference was not statistically significant. Furthermore the DBSG showed a potential for change between baseline and 12 weeks for the functional balance outcome, the BBS, however the difference was not statistically significant. A study with a larger sample size may have provided more statistical power to these results. Certain individual differences such as age and BMI may have had an effect on the outcome variables, and thus could be considered con-founding variables. Due to the small sample size however statistical analysis using these con-founding variables was limited.

Many studies have looked at 50 hours of exercise (this would equate to a 6 month intervention) as the gold standard in effectively addressing fall risk. Therefore, it may be beneficial to lengthen the intervention to see if this has a positive effect on the results. A long term follow up of six to twelve months may provide some much needed research on the long term effects of these type of interventions and assist in understanding what type of maintenance programmes are necessary in order to preserve strength gains achieved as a result of the study.

In addition to this, it may be useful to introduce a control group, in order to measure the effects of ageing on fall risk outcomes, however, lack of resources did not allow for this. It is important in a fall risk study to also look at fall rates in response to the two exercise interventions. Although we can see some improvement in the outcome measures that measure fall risk, it would be beneficial to see if reducing their fall risk in fact reduces the amount of falls they may experience. In addition to this, future studies should isolate components of fall prevention exercise programmes in order to determine more clarity on the specific exercises that are most effective in reducing fall risk.

Future studies should compare the number medications and the type of medication used on fall risk outcomes in order to describe and explore the effects of medication on balance.

Furthermore, fall history data and number of falls 6 and/or 12 months after an exercise intervention should be collected in future studies, as previous falls would have influenced levels of anxiety and FES-I results and it would be useful to see the effect of the intervention(s) on future falls.

Major cognitive impairment, although this was added in the exclusion criteria, was not assessed by the researcher. In order to avoid bias or misclassification of participants, future studies should assess cognitive status in the form of a (Mini-mental state examination) MMSE, level of education as well as sociocultural factors. In addition, postural hypotension should be an exclusion criterion in future studies, as this state of lowered blood pressure often leads to dizziness and loss of balance, which is dangerous in an exercise class environment. Furthermore, other physical activity should have been recorded prior to and during the exercise intervention, to monitor the effects of the intervention on the more active participants. Finally, another limitation of this study may be the fact that on average, the participants were not categorised as having a high risk of falling by all of the outcome measures. Some of the outcome measures (BBS and TUG) suggested that on average the risk of falling was in fact considered low, while other outcome measures suggested moderate to high risk of falling (FTSST and FES-I). Future studies could group high risk participants, and compare the change in fall risk outcomes between different fall risk categories after various exercise interventions. This would provide knowledge on what exercise interventions work best for the various levels of fall risk seen in older adults

5.10 Take home message

Table 11: Facts known about the topic and the take home message.

Facts known about the topic:
The geriatric population is growing exponentially, and although this is a good reflection on the efficiency of health care, this has major economic and social implications on families, communities and healthcare systems [10, 22].
Falls are a common problem for older adults; 30% of adults over the age of 65 years [25] and 50% of adults aged 80 years and older, fall annually [13].
Exercise is seen as the most effective intervention for reducing the risk of falls in older adults [20], however not enough is known about exactly what type of exercise is most effective [139].
There is mixed opinion regarding optimal length of an exercise intervention for reducing fall risk [144]. Some studies found significant differences after 8 weeks [110], however most studies seem to include more than 50 hours of exercise, and many studies indicate that exercise programmes need to be on-going in order to not lose the benefits gained [105].
Facts that this study adds to the topic:
Exercise interventions that are based on dynamic balance and stepping are more effective in reducing fall risk than general exercise programmes that involve no balance elements. These results are specifically noted in functional strength and balance outcomes such as the FTSST, BBS and postural sway measures on a foam surface with eyes open.
Exercise interventions that focus on general exercises are possibly better at improving mobility in the elderly.
Fall prevention exercise programmes need to be longer than 8 weeks, as significant improvements were noted between the 8 and 12 week time frame.
On the basis of this study, therapists should be encouraged to incorporate an element of balance and dynamic stepping into their fall risk exercise programmes.

5.11 Conclusion

Exercise therapists need to deliver programmes that are effective and efficient, in order to successfully improve outcomes for older adults who are at risk of falling. The current study has discussed the importance of exercise as an intervention to prevent falls in older adults. This study has made a head-to-head comparison of two different exercise programmes in terms of reducing fall risk, in order to understand which exercise programme would be more effective in improving fall risk outcomes. In addition, this study has made mid and post-intervention comparisons of outcome values, in an attempt to see where the change in both groups occurred. This has provided information on how long the exercise interventions need to be in order to see sufficient results.

Exercise interventions have been well documented in the literature as an effective method of reducing falls in older adults [105]. Many exercise interventions are multicomponent, and include gait, functional, strengthening, flexibility and endurance exercises [163]. In addition, many of the studies that proved to be effective for fall risk reduction include a balance component [163]. Although many of these programmes have proved successful, researchers and exercise therapists alike are left unaware of which component is best [108].

Few studies have assessed incidence of falls, and many use fall risk outcome measures such as the FTSST, BBS, TUG [79]. Indeed, the results have indicated that both exercise programmes benefit fall risk, however the DBSG showed improvement in more of the fall risk outcomes and specifically in the functional balance assessment when the two groups were compared to one another, the DBSG scored better than the GEG. Therefore exercise programmes that emphasise dynamic balance and stepping abilities are more effective in reducing fall risk outcomes in older adults, when compared to general exercise programmes.

There are certain limitations to the assessments used, and this needs consideration when analysing the effect that the interventions had on the various outcome measures. There is a celling effect that is observed in the BBS test, and authors have noted that a limitation to the scale is the lack of assessing postural response to external stimuli or uneven support surfaces [167]. The TUG test also displays a ceiling effect, and therefore at a certain point no further changes to the score will occur irrespective of the intervention [168]. This could perhaps explain why the DBSG didn't show significant changes in this outcome variable, since the group at baseline had a lower score than the post-intervention score for the GEG, thus the intervention would have a limited effect on changing this score. In addition, scores for the GEG showed a tendency to worsen between baseline and the mid-intervention assessment; this could be due to predictive validity of the FES-I still needing to be confirmed.

Environments or body positions that challenge balance and proprioceptive systems should be synthesised into all forms of exercise that at risk individuals perform. Floor surfaces and sitting surfaces should be progressed to foam balance and balls. These kinds of balance skills seem to be crucial in fall prevention exercise interventions, and should be included in any fall prevention programme.

This study has compared two programmes to see which type of exercise is more effective in reducing fall risk outcomes. The results indicate that a general exercise programme may in fact lack the important benefits and may not be as beneficial as a dynamic balance and stepping programme for reducing risk of falling. Exercise therapists should emphasise dynamic balance and stepping exercises in fall prevention programmes, and these programmes should run for at least 12 weeks to see adequate change in fall risk outcomes. To the best of the researcher's knowledge, this study was a first of its kind in

South Africa, and the beginning of journey in understanding falls in older adults and way in which fall risk outcomes can be improved.

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Appendixes

Appendix A: Presentations

alzheimer's South Africa
facing the challenge of dementia

12th September 2014

TO WHOM IT MAY CONCERN

I wish to confirm that Hannah Raath presented her research findings on the risk of falling in older adults at the 5th annual Alzheimer's SA seminar held in Johannesburg on 10th September 2014. The title being, "A comparison of the effectiveness of two different exercise interventions in reducing the risk of falling in older adults in Gauteng."

Topics presented along similar lines in older care included, "Get up and Go" by Anna Bizos (physiotherapist) and "One Swallow does not Make a Meal" by Ruthann Sedgwick (Speech and Language Therapist/Audiologist)

Ms Raath's presentation was very well received.

Your Sincerely,
Loraine Schirlinger
(Regional Director, Gauteng)

NOFSA
NATIONAL OSTEOPOROSIS FOUNDATION, SOUTH AFRICA
t +27(0)21 976 4995
f +27(0)21 976 4999
e info@osteoporosis.org.za
w www.osteoporosis.org.za
PO Box 3761, Durbanville, 7551
Somerset Building 2, Suite 5
Cnr Paul Kruger and Somerset Crescent, Durbanville, South Africa
Established: 1993 NPO 004-287

10 November 2014

TO WHOM IT MAY CONCERN

Dear Sir/Madam

This letter serves to confirm that Ms Hannah Raath delivered a talk on "Fall prevention, balance and exercise prescription in older adults" at our recent NOFSA Conference on 25 October 2014.

Regards



Teréza Hough

OSTEOPOROSIS IS A SILENT DISEASE. MAKE A NOISE!

COUNCIL: Prof S. Hough (chairman), Dr T. de Villiers (Vice-Chair) Dr S. Brown, Prof B. Cassim, Dr M. Davey, Dr G. Ellis, Dr S.Lipschitz, Prof M. Lukhele, Prof J. Pettifor, Dr W de Lange.

SATURDAY, 25 OCTOBER

08:00 – 10:30	SESSION VII	Chairperson: Dr. Farhanah Paruk
08:00	**Advanced Imaging of Bone Structure and Strength in Osteoporosis.**	*Harry Genant, Professor Emeritus of Radiology, Orthopedic Surgery, Medicine and Epidemiology, University of California San Francisco and Co-Founder and Senior Consultant, Synarc, USA.*
09:00	**Sarcopaenia and frailty.**	*Willie Mollentze, Emeritus Professor of Medicine and Endocrinology, University of the Free State, Bloemfontein, South Africa.*
09:30	**Falls in the elderly.**	*Brent Tipping, Sub-specialist Geriatrician and Specialist Physician, Academic Private Practice at the Wits Donald Gordon Medical Center, Parktown and Head of the Division of Geriatric Medicine, University of the Witwatersrand, Johannesburg.*
10:00	**Falls prevention, balance and exercise prescription in older adults.**	*Hannah Raath, Biokineticist in Private Practice, Melrose, South Africa.*
10:30 – 11:00	TEA / COFFEE	
11:00 – 13:00	SESSION VIII	Chairperson: Dr Graham Ellis
11:00	**Recent advances in DXA technologies and applications.**	*Harry Genant, Professor Emeritus of Radiology, Orthopedic Surgery, Medicine and Epidemiology, University of California San Francisco and Co-Founder and senior Consultant, Synarc, USA.*
11:45	**Menopausal hormone therapy – 2014.**	*Tobie de Villiers, Consultant Gynaecologist Panorama MediClinic and Department of Obstetrics and Gynaecology, Stellenbosch University, and President: International Menopause Society.*

OSTEOPOROSIS IS A SILENT DISEASE. MAKE A NOISE!

JGPT Submission Confirmation for:

COMPARING THE EFFECTIVENESS OF A GENERAL EXERCISE PROGRAM AND A DYNAMIC BALANCE AND STEPPING PROGRAM ON REDUCING FALLS RISK OUTCOMES IN OLDER ADULTS.

JGPT **<em@editorialmanager.com>**

02/24/2015

Dear Ms Raath,

Your submission entitled "COMPARING THE EFFECTIVENESS OF A GENERAL EXERCISE PROGRAM AND A DYNAMIC BALANCE AND STEPPING PROGRAM ON REDUCING FALLS RISK OUTCOMES IN OLDER ADULTS." has been received by the journal editorial office.

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author.

http://jgpt.edmgr.com/

Your manuscript will be given a reference number once an Editor has been assigned.

Thank you for submitting your work to this journal.

Kind Regards,

Journal of Geriatric Physical Therapy

Appendix B: Oxford University Press License Terms and Conditions

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Jan 17, 2015

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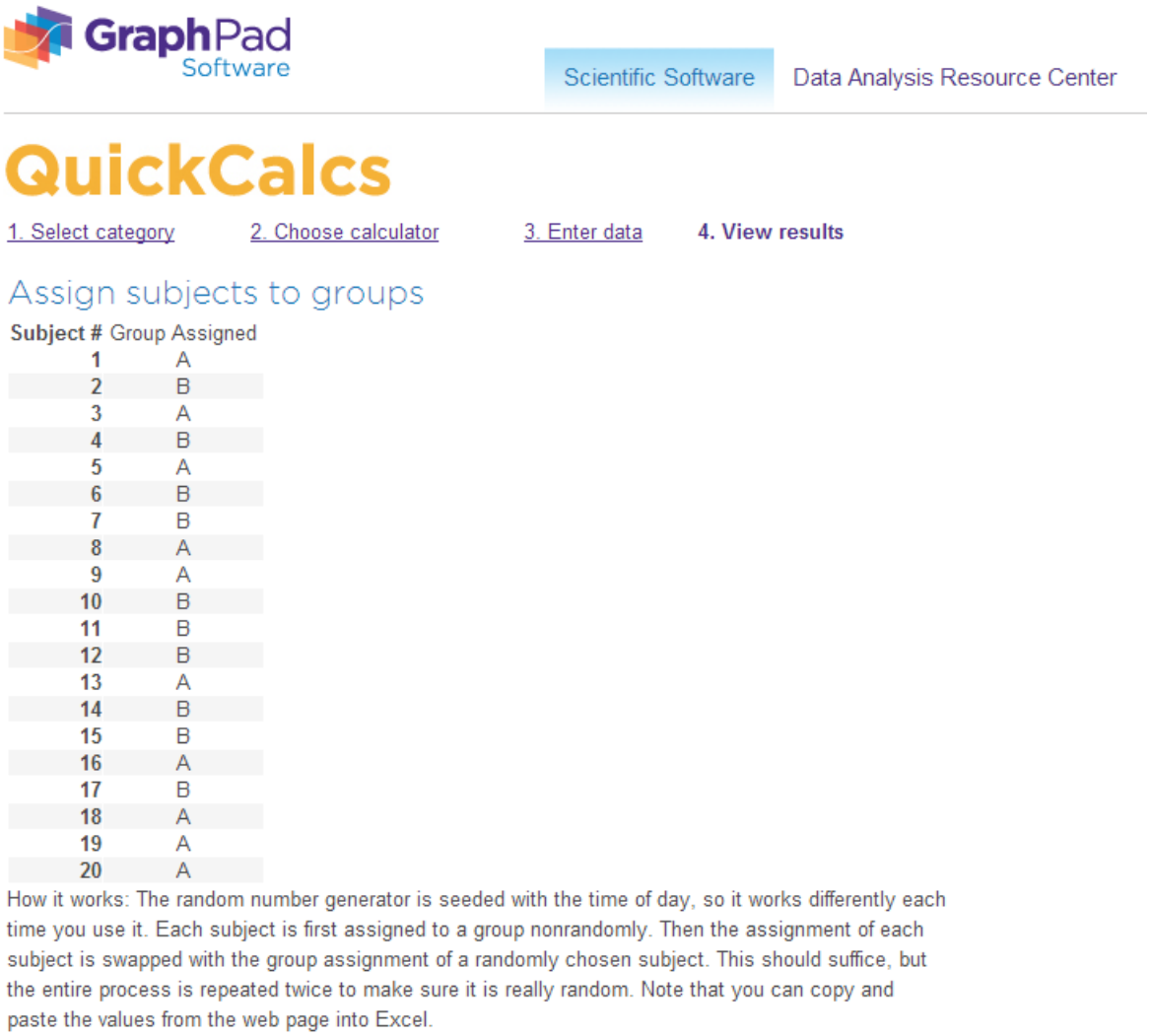
Appendix C: Random allocation



GraphPad Software

Scientific Software | Data Analysis Resource Center

QuickCalcs

1. Select category | 2. Choose calculator | 3. Enter data | **4. View results**

Assign subjects to groups

Subject #	Group Assigned
1	A
2	B
3	A
4	B
5	A
6	B
7	B
8	A
9	A
10	B
11	B
12	B
13	A
14	B
15	B
16	A
17	B
18	A
19	A
20	A

How it works: The random number generator is seeded with the time of day, so it works differently each time you use it. Each subject is first assigned to a group nonrandomly. Then the assignment of each subject is swapped with the group assignment of a randomly chosen subject. This should suffice, but the entire process is repeated twice to make sure it is really random. Note that you can copy and paste the values from the web page into Excel.

QuickCalcs

1. Select category | 2. Choose calculator | 3. Enter data | **4. View results**

Assign subjects to groups

Subject #	Group Assigned
1	A
2	B
3	A
4	A
5	B
6	A
7	A
8	A
9	A
10	B
11	B
12	B
13	B
14	B
15	A
16	A
17	B
18	B
19	A
20	B

How it works: The random number generator is seeded with the time of day, so it works differently each time you use it. Each subject is first assigned to a group nonrandomly. Then the assignment of each subject is swapped with the group assignment of a randomly chosen subject. This should suffice, but the entire process is repeated twice to make sure it is really random. Note that you can copy and paste the values from the web page into Excel.

QuickCalcs

1. Select category | 2. Choose calculator | 3. Enter data | **4. View results**

Assign subjects to groups

Subject #	Group Assigned
1	B
2	A
3	B
4	A

How it works: The random number generator is seeded with the time of day, so it works differently each time you use it. Each subject is first assigned to a group nonrandomly. Then the assignment of each subject is swapped with the group assignment of a randomly chosen subject. This should suffice, but the entire process is repeated twice to make sure it is really random. Note that you can copy and paste the values from the web page into Excel.

Appendix D: Ethics approval

M130446

R14/49 Ms Hannah Raath

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M130446

NAME: (Principal Investigator)	Ms Hannah Raath
DEPARTMENT:	Centre for Exercise Science & sports Medicine Medical School
PROJECT TITLE:	A Comparison of the Effectiveness of Two Different Exercise Interventions in Reducing the Risk of Falling in Older Adults in Gauteng
DATE CONSIDERED:	26/04/2013
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Ms Estelle Watson
APPROVED BY:	Professor PE Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 14/06/2013

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix E: INFORMATION LEAFLET AND INFORMED CONSENT

STUDY TITLE:

"A comparison of the effectiveness of two different exercise interventions in reducing the risk of falling in older adults in Gauteng".

INVESTIGATOR:

Hannah Raath

INSTITUTION:

University of the Witwatersrand

DAYTIME TELEPHONE NUMBER(S):

011 880 4719 and 082 853 4432

AFTER HOURS TELEPHONE NUMBER:

082 853 4432

ADDRESS WHERE THE EXERCISE CLASSES WILL TAKE PLACE

Melrose North Medical and Dental Centre

82 Corlett Drive

Melrose North

Johannesburg

ADDRESS WHERE THE INITIAL AND FINAL TESTING WILL TAKE PLACE

Physical Education Building, Wits Education Campus, 27 St. Andrew's Road, Parktown.

To the potential participant: This consent form may contain words that you do not understand. Please ask the researcher or the study staff to explain any words or information that you do not clearly understand. You may take home an **unsigned copy of this consent form** to think about or discuss with family or friends **before making your decision**

INTRODUCTION:

Good day, my name is Hannah Raath, I am a registered biokineticist and I work at my practice in Melrose North. The patients that I treat are mainly older adults. I prescribe exercise for various physical conditions and injuries. My main area of interest is fall prevention, and how to use exercise to decrease the risk of having a fall. I am doing research for my Master's degree through the University of the Witwatersrand, and I would like to invite you to consider participating in this research study. The title of the research is: "A comparison of the effectiveness of two different exercise interventions in reducing the risk of falling in older adults in Gauteng".

Exercise has been shown to be effective in reducing the risk of falls in older adults, as it improves balance, strength and overall physical fitness. This research is aimed at comparing the effectiveness of two types for exercise programmes in reducing the risk of falls in older adults. This will hopefully allow us to understand exactly which type of exercise is more effective in improving balance and reducing fall risk.

1. Before agreeing to participate, it is important that you read and understand the following explanation of the purpose of the study, the study procedures, benefits, risks, discomforts and precautions as well as your right to withdraw from the study at any time. This information leaflet is to help you to decide if you would like to participate. You need to understand what is involved before you agree to take part in this study.
2. If you have any questions, do not hesitate to ask me.
3. You should not agree to take part unless you are satisfied about all the procedures involved.
4. Participation in the study is voluntary, and refusal to participate will involve no penalty, you may discontinue participation without prejudice.
5. You have been invited to participate because you a 65 years or older, and could be at risk of falling.
6. You should not have participated in a fall prevention programme or balance training within the past 3 months.
7. Please be open with me regarding your health history, so that I can ensure your health safety at all times during the exercise programme.
8. If you decide to take part in this study, you will be asked to sign this document to confirm that you understand the study. You will be given a copy to keep.
9. If you have a personal doctor, please discuss with or inform him/her of your possible participation in this study. If you wish, I can also notify your personal doctor in this regard.

9. LENGTH OF THE STUDY

- The study will run for 12 weeks.
- You will be asked to attend 2 exercise classes per week.

10. PROCEDURES:

- If you agree to take part in this study, you will first be asked questions and examined to see if you qualify for this study.
- Before you participate in the first exercise class, you will be randomly allocated to one of two exercise groups; either the general exercise class or the dynamic balance and stepping exercise class.
- Before we begin with the classes your baseline measures will be recorded.
- We will record your:
    - Next of kin contact details
    - House doctor name
    - Medication list
    - Age

    - Gender
- We will ask you to complete a pre-participation questionnaire, to assess if it is safe for you to exercise, and ask you details about your medical history, symptoms, and cardiovascular risks.
- You will be required to complete a second questionnaire that will ask you how comfortable you are with completing various physical tasks and household chores.
- We will measure your:
    - Weight and height.
    - Blood pressure and heart rate while lying down and while standing.
    - Time taken to stand up from a chair and sit down again, five times.
    - Time taken to stand up from a chair, walk 3 meters, turn around, walk back to the chair and return to the seated position.
    - Balance ability (with assistance if needed) while you complete a series of tasks that involve sitting and standing up from a chair, walking 3 meters and turning around, standing on one leg, standing with feet together and one-foot in front of the other, reaching forward and lifting feet onto a step.
    - Balance skill while standing on the biodex balance plate (a surface that moves slightly, and requires the participant to try and stay stable). There are secure bars around the machine, to assist you during the exercise.

There will be no charge for the exercise classes for the period of the 12 week study. Each class will have 10 participants and 2 qualified exercise instructors. At the 8 week time frame, a mid-trial assessment will be completed, whereby your balance and strength measures will be repeated. At the end of the study the same measurements and tests that will be completed before the study, will be repeated, this will allow us to see if any improvements have been made due to the 12 week exercise programme.

Both classes will begin with a light warm up routine and a few gentle stretches. This will be followed by a routine of exercises that the instructors will explain and demonstrate and let you attempt them on your own. If you need assistance with any of the exercises, the instructors will be able to help. Any questions about the exercises can be asked at any stage. The intensity of the exercise will be adjusted to suit your ability. Many of the exercises are performed in a seated position, and some are performed standing (while holding onto a secure rail if needed). Our aim is to have you participating in the classes and managing the exercises so that you feel comfortable, and enjoy yourself. Some people might be fitter or stronger than other people, or the other way around, that is not a problem, the exercises are easily adaptable to suit your needs. The exercises that are used in the classes are well researched and have been found to be safe and benefit older adults. The exercise class will end with a short cool down period and a few other stretches.

Water will be available after the exercise classes, also lavatory facilities available, if needed, at the studio where the exercises will take place.

During the course of the study you will be asked to keep a record of any falls that you may have over the 12 week period. If you fall, you will be asked to record: How you did you fall? What surface you were on when you fell? What you were doing when you fell? What injuries you sustained when you fell? You will be given a falls diary to make it easier for you to make these notes.

11. WILL ANY OF THESE STUDY PROCEDURES RESULT IN DISCOMFORT?

- Exercise may cause slight muscles discomfort a day or two after the exercise session; this may occur if the muscles used in a particular exercise are not used to being worked. The discomfort should ease after 1-3 days, and as the exercises become more familiar less or no discomfort should be experienced. The design of the exercise programmes, (suitable gentle warm up and cool down routine and light stretching at the beginning and end of the exercise session) will help to reduce the risk of muscle soreness.

12. RISKS ASSOCAITED WITH EXERCISE

- There is a risk of injury and joint pain while participating in the exercise classes if you do the exercise incorrectly or the intensity of the exercise is too high. Don't push yourself beyond your comfort level. The exercise instructors will also make sure that the intensity of the classes is not too heavy and that you are slowly eased onto the exercise routine.
- Fatigue and dehydration could result if you are not used to exercise and don't drink enough water, the exercise instructors will ensure water breaks are included into the exercise session.
- Low blood pressure and blood sugar could result from exercise if you are not used to exercise or haven't eaten a substantial meal; we recommend you eat 2 hours before the class begins.
- While participating in the exercise there is a risk of you falling or losing your balance, we need you to make sure you concentrate well while doing the exercises. To further ensure your safety there will be secure bars and chairs to hold onto while exercising.

14. BENEFITS:

- Exercise benefits include improved fitness, general strength and flexibility
- Improved balance and stability and a potential reduced fall risk
- Improved walking ability
- Your participation in this study will contribute to medical knowledge that may help other older adults who are at risk of falling
- Benefits from the study are not guaranteed.

RIGHTS AS A PARTICIPANT IN THIS STUDY:

Your participation in this study is entirely voluntary and you can decline to participate, or stop at any time, without stating any reason.

18. Withdrawal:

- Your withdrawal will not affect your access to other medical care.
- I retain the right to withdraw you from the study if it is considered to be in your best interest. If your participation is ended early, you may be asked to return for study-ending tests and procedures for your safety
- If you did not give an accurate history or did not follow the guidelines of the study and the regulations of the study facility, you may be withdrawn from the study at any time.

25. ETHICAL APPROVAL:

- This clinical study protocol has been submitted to the University of the Witwatersrand, **Human Research Ethics Committee (HREC)** and written approval has been granted by that committee.
- The study has been structured in accordance with the **Declaration of**

Helsinki (last updated: October 2008), which deals with the recommendations guiding health professional in biomedical research involving human participants. A copy may be obtained from me should you wish to review it.

- If you want any information regarding your **rights as a research participant, or complaints regarding this research study**, you may contact Prof. Cleaton-Jones, Chairperson of the University of the Witwatersrand, Human Research Ethics Committee (HREC), which is an independent committee established to help protect the rights of research participants at (011) 717 2301.

28. **CONFIDENTIALITY:**

All information obtained during the course of this study, including hospital records, personal data and research data will be kept strictly confidential unless in the event that the information is required by law.

- Data that may be reported in scientific journals will not include any information that identifies you as a participant in this study.
- The information might also be inspected by the University of the Witwatersrand, Human Research Ethics Committee (HREC).
- These records will be utilised by them only in connection with carrying out their obligations relating to this clinical study, records may be stored for future studies.
- You will be informed of any findings of importance to your health or continued participation in this study but this information will not be disclosed to any third party in addition to the ones mentioned above without your written permission

29. PERSONAL DOCTOR / SPECIALIST

NOTIFICATION OPTION:

Please indicate below, whether you want me to notify your personal doctor or your specialist of your participation in this study:

- **YES**, I want you to inform my personal doctor / specialist of my participation in this study.
- **NO**, I do not want you to inform my personal doctor / specialist of my participation in this study.
- **I do not have** a personal doctor / specialist

30. PARTICIPANT QUESTIONS*?*

Did the participant raise any questions?

YES / NO

If YES – What where they:

_____
_____
_____
_____
_____
_____
_____
_____

INFORMED CONSENT:

- I hereby confirm that I have been informed by the researcher, Hannah Raath, about the nature, conduct, benefits and risks of clinical study: **"A comparison of two different exercise interventions in reducing the risk of falling in older adults in Gauteng"**.
- I have also received, read and understood the above written information (Participant Information Leaflet and Informed Consent) regarding the clinical study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by Hannah Raath or on her behalf.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

PARTICIPANT:

Printed Name Signature / Mark or Thumbprint Date and Time

I, Hannah Raath herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

STUDY RESEARCHER:

Printed Name Signature Date and Time

Appendix F: Baseline, Mid and Post-intervention Data sheet

Data collector information:	
Name of person collecting data:	
Date:	
Location of data collection:	

Research participant information:	
Participant code:	
In the event of an emergency, please provide the following details:	
Next of kin name and surname:	
Relationship to participant:	
Contact details:	Home:
	Cell:
	Work:
Doctor's name:	
Doctor's contact details:	
Doctor's address:	

Age (years and months):	
Gender:	
Height (cm):	
Weight (kg):	
BMI:	
Supine resting heart rate (beats per minute):	
Standing resting heart rate (beats per minute):	
Supine resting blood pressure (mmHg):	
Standing resting blood pressure (mmHg):	

Medication list:

Allergies: _____

Medications I take (Prescription, Non- prescription, Vitamins and Supplements)				
What I take?	Why I take it	Dosage	When I take it?	How often taken?
E.g. Lipitor	E.g. Cholesterol	E.g. 20 mg	E.g. at night	E.g. once a day

I, _____, have disclosed the correct information to the best of my knowledge and do realise that this information will be kept confidential by my Biokineticist. I understand that disclosing this information can help my Biokineticist treat me holistically, and prevent adverse interactions between any medication and exercise.

Participant signature: _____ Date: _____

AHA/ACSM pre-participation screening questionnaire [9]:

PRE-PARTICIPATIONSCREENING QUESTIONNAIRE

The study researcher will help you to fill this form out, please feel free to ask any questions. Answer the following questions to the best of your ability. Only tick what applies to you. All your information is kept confidential and will be used for the sole purpose of designing a safe exercise programme. This form is adapted from the American College of Sports Medicine (ACSM) guidelines for risk stratification form.

History:

Please tick if you have had any of the following?

___A heart attack
___Heart surgery
___Cardiac catheterisation
___Coronary angioplasty (PTCA)
___Pacemaker/implantable cardiac defibrillator or rhythm disturbance
___Heart value disease
___Heart failure
___Heart transplantation
___Congenital heart disease

Symptoms:

Do you suffer from (please tick):

___Chest discomfort with exertion
___Breathlessness
___ Dizziness, fainting, blackouts

Do you have any of these health issues?

(Please tick)

___Diabetes
___Asthma or other lung disease
___Burning or cramping in your lower legs
___Musculoskeletal problems that limit your physical activity
___Concerns about the safety of exercise
___ You take heart medications

Cardiovascular risk factors

(Please tick):

___Are you a man older than 45 years?
___Are a woman older than 55 years or you have had a hysterectomy or you are post-menopausal?
___ Do you smoke or have you quit smoking within the past 6 months?
___Is your blood pressure is greater than 140/90mmHg or you don't know your blood pressure?
___Do you take blood pressure medication?
___Is your cholesterol is great than 5 mmol/L, or you don't know your cholesterol level?
___Do you have a close relative who has had a heart attack before 55 (brother or father) or age 65 (sister or mother)?
___ Are you physically inactive (i.e.: you get less than 30 minutes of exercise on at least three days)?
What is your weight? _____Kg
What is your height? _____m

I certify my answers to the above questions are correct and truthful to the best of my knowledge. If I experience any changes in my health status during the course of my treatment, I will notify one of the researchers immediately. It is my responsibility to seek medical supervision if any worsening of my health status occurs.

Participant's name: _____ Researcher's name_____

Participant's signature: _____ Researcher's signature: _____

Date: _____ Date: _____

Outcome variable data:

Five times sit to stand score	
Result:	
Comments:	

Timed up and go test	
First trial test (seconds):	
Second trial test (seconds):	
Average time: (seconds):	

Biodex test: Overall balance index (Fall risk test)	
Result:	
Comments:	

Biodex test: Modified Clinical Test of Sensory Integration and Balance	
Condition:	**Sway Index:**
Eyes open, firm surface	
Eyes closed, firm surface	
Eyes open, foam surface	
Eyes closed, foam surface	
Comments:	

Falls Efficacy. Scale- International				
	Not at all concerned (1)	Somewhat concerned (2)	Fairly concerned (3)	Very concerned (4)
Cleaning the house (e.g.: sweep, vacuum or dust)				
Getting dressed or undressed				
Preparing simple meals				
Taking a bath or shower				
Going shopping				
Getting in or out of a chair				
Going up or down stairs				
Walking around the neighbourhood				
Reaching for something above your head or the ground				
Going to answer the telephone before it stops ringing				
Walking on a slippery surface (e.g.: wet and icy)				
Visiting a friend or a relative				
Walking in a place with crowds				
Walking on an uneven surface (e.g.: rocky ground, poorly maintained pavement)				
Walking up or down a slope				
Going out to a social event (e.g.: religious service, family gathering or club meeting)				

Outcome variable data continued:

Berg balance scale results	
Item description:	Score (1-4)
Sitting to standing	
Standing unsupported	
Sitting unsupported	
Standing to sitting	
Transfers	
Standing with eyes closed	
Standing with feet together	
Reaching forward with outstretched arm	
Retrieving object from floor	
Turning to look behind	
Turning 360 degrees	
Placing alternate foot on stool	
Standing with one foot in front	
Standing on one foot	
Total score:	
Comments:	

Appendix G: Falls Efficacy Scale-International (FES-I) [128].

I would like to ask some questions about how concerned you are about the possibility of falling. For each of the following activities, please tick the opinion closest to your own to show how concerned you are that you might fall if you did this activity. Please reply thinking about how you usually do the activity. If you currently don't do the activity (example: if someone does your shopping for you), please answer to show whether you think you would be concerned about falling IF you did the activity.

Falls Efficacy. Scale- International				
	Not at all concerned (1)	Somewhat concerned (2)	Fairly concerned (3)	Very concerned (4)
Cleaning the house (e.g.: sweep, vacuum or dust)				
Getting dressed or undressed				
Preparing simple meals				
Taking a bath or shower				
Going shopping				
Getting in or out of a chair				
Going up or down stairs				
Walking around the neighbourhood				
Reaching for something above your head or the ground				
Going to answer the telephone before it stops ringing				
Walking on a slippery surface (e.g.: wet and icy)				
Visiting a friend or a relative				
Walking in a place with crowds				
Walking on an uneven surface (e.g.: rocky ground, poorly maintained pavement)				
Walking up or down a slope				
Going out to a social event (e.g.: religious service, family gathering or club meeting)				

Appendix H: Berg Balance Scale [133].

Berg Balance Scale

ITEM DESCRIPTION	SCORE (0-4)
1. Sitting to standing	_____
2. Standing unsupported	_____
3. Sitting unsupported	_____
4. Standing to sitting	_____
5. Transfers	_____
6. Standing with eyes closed	_____
7. Standing with feet together	_____
8. Reaching forward with outstretched arm	_____
9. Retrieving object from floor	_____
10. Turning to look behind	_____
11. Turning 360 degrees	_____
12. Placing alternate foot on stool	_____
13. Standing with one foot in front	_____
14. Standing on one foot	_____

Total _____

GENERAL INSTRUCTIONS

Please document each task and/or give instructions as written. When scoring, please record the lowest response category that applies for each item.

In most items, the subject is asked to maintain a given position for a specific time. Progressively more points are deducted if:

- the time or distance requirements are not met
- the subject's performance warrants supervision
- the subject touches an external support or receives assistance from the examiner

Subject should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.

Equipment required for testing is a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5, and 10 inches. Chairs used during testing should be a reasonable height. Either a step or a stool of average step height may be used for item # 12.

Berg Balance Scale

1. SITTING TO STANDING

INSTRUCTIONS: Please stand up. Try not to use your hand for support.

( ) 4 able to stand without using hands and stabilize independently

( ) 3 able to stand independently using hands

( ) 2 able to stand using hands after several tries

( ) 1 needs minimal aid to stand or stabilize

( ) 0 needs moderate or maximal assist to stand

2. STANDING UNSUPPORTED

INSTRUCTIONS: Please stand for two minutes without holding on.

( ) 4 able to stand safely for 2 minutes

( ) 3 able to stand 2 minutes with supervision

( ) 2 able to stand 30 seconds unsupported

( ) 1 needs several tries to stand 30 seconds unsupported

( ) 0 unable to stand 30 seconds unsupported

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

3. SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL

INSTRUCTIONS: Please sit with arms folded for 2 minutes.

( ) 4 able to sit safely and securely for 2 minutes

( ) 3 able to sit 2 minutes under supervision

( ) 2 able to able to sit 30 seconds

( ) 1 able to sit 10 seconds

( ) 0 unable to sit without support 10 seconds

4. STANDING TO SITTING

INSTRUCTIONS: Please sit down.

( ) 4 sits safely with minimal use of hands

( ) 3 controls descent by using hands

( ) 2 uses back of legs against chair to control descent

( ) 1 sits independently but has uncontrolled descent

( ) 0 needs assist to sit

5. TRANSFERS

INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.

( ) 4 able to transfer safely with minor use of hands

( ) 3 able to transfer safely definite need of hands

( ) 2 able to transfer with verbal cuing and/or supervision

( ) 1 needs one person to assist

( ) 0 needs two people to assist or supervise to be safe

6. STANDING UNSUPPORTED WITH EYES CLOSED

INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.

( ) 4 able to stand 10 seconds safely

( ) 3 able to stand 10 seconds with supervision

( ) 2 able to stand 3 seconds

( ) 1 unable to keep eyes closed 3 seconds but stays safely

( ) 0 needs help to keep from falling

7. STANDING UNSUPPORTED WITH FEET TOGETHER

INSTRUCTIONS: Place your feet together and stand without holding on.

( ) 4 able to place feet together independently and stand 1 minute safely

( ) 3 able to place feet together independently and stand 1 minute with supervision

( ) 2 able to place feet together independently but unable to hold for 30 seconds

( ) 1 needs help to attain position but able to stand 15 seconds feet together

( ) 0 needs help to attain position and unable to hold for 15 seconds

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING

INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)

( ) 4 can reach forward confidently 25 cm (10 inches)

( ) 3 can reach forward 12 cm (5 inches)

( ) 2 can reach forward 5 cm (2 inches)

( ) 1 reaches forward but needs supervision

( ) 0 loses balance while trying/requires external support

9. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION

INSTRUCTIONS: Pick up the shoe/slipper, which is place in front of your feet.

( ) 4 able to pick up slipper safely and easily

( ) 3 able to pick up slipper but needs supervision

( ) 2 unable to pick up but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently

( ) 1 unable to pick up and needs supervision while trying

( ) 0 unable to try/needs assist to keep from losing balance or falling

10. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.

( ) 4 looks behind from both sides and weight shifts well

( ) 3 looks behind one side only other side shows less weight shift

( ) 2 turns sideways only but maintains balance

( ) 1 needs supervision when turning

( ) 0 needs assist to keep from losing balance or falling

11. TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

( ) 4 able to turn 360 degrees safely in 4 seconds or less

( ) 3 able to turn 360 degrees safely one side only 4 seconds or less

( ) 2 able to turn 360 degrees safely but slowly

( ) 1 needs close supervision or verbal cuing

( ) 0 needs assistance while turning

12. PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touch the step/stool four times.

( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds

( ) 3 able to stand independently and complete 8 steps in > 20 seconds

( ) 2 able to complete 4 steps without aid with supervision

( ) 1 able to complete > 2 steps needs minimal assist

( ) 0 needs assistance to keep from falling/unable to try

13. STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width.)

( ) 4 able to place foot tandem independently and hold 30 seconds

( ) 3 able to place foot ahead independently and hold 30 seconds

( ) 2 able to take small step independently and hold 30 seconds

( ) 1 needs help to step but can hold 15 seconds

( ) 0 loses balance while stepping or standing

14. STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding on.

( ) 4 able to lift leg independently and hold > 10 seconds

( ) 3 able to lift leg independently and hold 5-10 seconds

( ) 2 able to lift leg independently and hold ≥ 3 seconds

( ) 1 tries to lift leg unable to hold 3 seconds but remains standing independently.

( ) 0 unable to try of needs assist to prevent fall

( ) TOTAL SCORE (Maximum = 56)

Appendix I: Dynamic balance and stepping class programme [137].

The Dynamic Balance and Stepping Group (DBSG) exercise programme	1 hour, twice a week.
1. <u>Warm up (total 15 minutes)</u>: Bar provided for upper body assistance if needed 	**Dose:**
○ Marching on the spot	2 minutes
○ Sideways walking	2-3 minutes
○ Walking on toes	2 minutes
○ Walking on heels	2 minutes
○ High knee marching with arms moving	2-3 minutes
○ Long step walking	2-3 minutes
2. <u>Centre of gravity training (total 25 minutes):</u> Ball base or chair, as well as bar was provided for upper body assistance if needed	
Seated on ball (own body weight):	
○ Shoulder abduction, alternating arms	6 repetitions, each arm
○ Shoulder flexion, and opposite arm flexion, alternating arms	6 repetitions, each arm
○ Trunk rotations	6 repetitions, each arm
○ Trunk lateral flexion	6 repetitions, each arm
○ Hip flexion	12 repetitions, each leg
○ Straight leg raise	12 repetitions, each leg
○ Ankle dorsi flexion	12 repetitions, each leg
○ Ankle planter flexion	
Standing balance:	
○ Standing with feet together	30 seconds
○ Standing with one foot directly in front of the other	30 seconds each foot leading
○ Standing on one leg	30 seconds on each foot
Multi directional weight shifts while standing:	
○ Wide stance forward and backward weight shift	6 repetitions each side
○ Wide stance lateral weight shift	6 repetitions each side
○ Progress to: wide stance forward diagonal weight shift	6 repetitions each side
○ Progress to: wide stance backward diagonal weight shift	6 repetitions each side
Dynamic weight transfers:	
○ Forward/backward foot tap onto target	6 repetitions each side
○ Progress to: sideways foot tap onto target	6 repetitions each side
Stepping exercises:	
○ Alternating foot touches onto step	1 minute
○ Single leg slow forward step up with balance	12 repetitions each leg

○ Single leg slow side step up with balance	12 repetitions each leg
2. <u>Multisensory training postural Strategy training (total 5 minutes):</u>	
○ Visual system balance control (walking across foam mat while concentrating on visual target)	2 minutes
○ Vestibular system balance control (closing eyes while balance on a foam surface)	2 minutes
○ Head and eye movements while walking along foam mat	1 minute
4. <u>Gait pattern training progression levels (total 15 minutes):</u>   	Total of 15 minutes
Level1: Walking with directional changes and abrupt stopping and starting	
Level 2: Walking with an altered base of support.	
o Narrow and wide step widths	
Level 3: Variations on gait patterns	
o Side stepping, braiding, and tandem walking	
Level 4: Obstacle negotiation	
o Walking between cones	
o Stepping over and onto objects like steps and balance pads	

[20, 137]

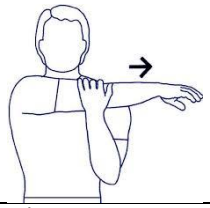
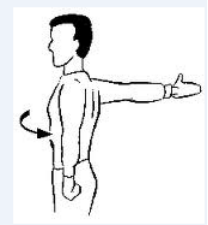
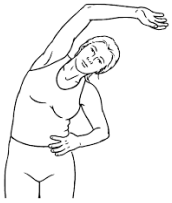
Appendix J: Modified Borg Scale.

Modified Borg scale (Rate of perceived exertion) [164].

0	Nothing at all
1	Very light
2	Fairly light
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Very, very hard

Appendix K: General exercise class programme.

Recommended guidelines set out by the ACSM [5]:

The General Exercise Group (GEG) exercise programme.
1. <u>Warm up and endurance training:</u> Alternating between 3 of the following, depending ability, 8 minutes on each machine:
○ Upright cycling
○ Treadmill walking
○ Arm ergometer
○ Rowing machine
2. <u>Flexibility training (10 minutes):</u> Completed seated and standing with support and assistance if needed, 2 repetitions, hold for 15 seconds each
Deltoids 
Triceps 
Chest/Bicep against wall 
Side lean 
Hamstring 

Calf



Quadriceps



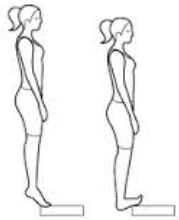
Gluteus



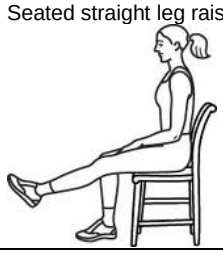
3. <u>Resistance training (20 minutes):</u>

Weights and resistance bands adjusted to suit ability of participant 5-6/10 relative intensity, 12 repetitions of each exercise

Calf raises



Seated straight leg raise



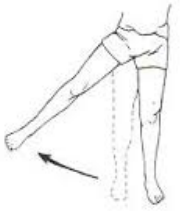
Knee squeezes (with ball)



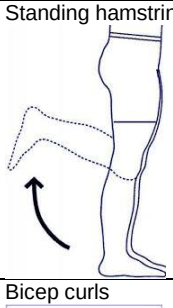
Seated abduction with resistance band



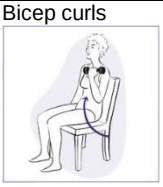
Standing straight leg side raises



Standing hamstring curls



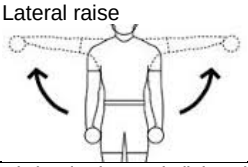
Bicep curls



Triceps extension



Lateral raise



Abdominal crunch (lying down)



4. <u>Cool down (6 minutes)</u>

Shoulder rolls 
Neck stretches 

[5]

Appendix L: Sample size calculation.

$N= \{Z^2 P(1-P)\}/d^2$

N=Sample size
Z= Z statistic for a level of confidence
P=Expected prevalence or proportion
d=Precision

Z=0.05
P=10% (P=0.1)
d= 0.05

N=139 (before taking into account drop out)

Considering a 20% drop out rate:

N= 139/ (1-0.2) =173

Therefore sample size should be N=173

Appendix M: Turnitin report.

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