The effects of dance on physical risk factors that influence falling in older adults

Stephen David Mann Chesterfield

A research thesis submitted in partial fulfilment of the requirements for the degree of Master of Osteopathy, Unitec Institute of Technology, 2013.
Declaration

Name of Candidate: Stephen David Mann Chesterfield

This Research Thesis titled “The effects of dance on influential physical risk factors for falling in older adults” is submitted in partial fulfilment of the requirements for the degree of Master of Osteopathy.

Candidate declaration:

I confirm that:

This research project represents my own work.

The contribution of supervisors and others to this work was consistent with the Unitec Regulation and Policies.

Research for this work has been conducted in accordance with the Unitec Research Ethics Committee Policy and Procedures, and has fulfilled any requirements set for this thesis by Unitec Research Ethics Committee.

Unitec Research Ethics Committee Approval Numbers: 2011-1199, 2011-1248

Student identification number: 1301788

Candidate Signature: Date:
Acknowledgements

There are a number of people and organisations that I would like to thank. To my superior supervisors, Catherine Bacon and Rob Moran, thank you for your infinite knowledge, understanding, patience and many hours of support. This research project is a small reflection of the time and energy you gave me. Thank you for helping me become an osteopath.

To Felicity Molloy, Ruth Ames and Terance James. Thank you for being such dedicated graceful dance instructors. You did a wonderful job for a noble research project. To the participants who took part in this study, thank you for dancing, it was all worth it. Keep enjoying the benefits of dance.

Thanks to the Osteopathic department at Unitec and Dance Aotearoa New Zealand for your support in subsidising dance classes to make them affordable for enthusiastic dance participants.

Thank you to my research colleague and friend Tania Russell. I can’t thank you enough for your amazing excel skills and data loving cerebrum. It was a pleasure to dance all the way through this research project with you, even with all the twists, spins and falls.

Last but not least thank you to my friends and family and of course my loving partner for making the best cup cakes for the very appreciative dance participants and putting up with me sitting behind a computer for hours on end.

Where there is movement there is life.
SECTION ONE: Literature Review

1.0 Introduction
1.1.1 Epidemiology and socioeconomic implications of falls in the older adults
1.1.2 Fall prevention in the New Zealand context
1.1.3 Fall-related injuries
1.1.4 Conditions that can predispose older adults to injuries
2.0 Risk factors for falling in older adults
2.1.1 Direct versus indirect outcome measures
2.1.2 Risk factors for falling
2.1.2.1 Lower extremity muscular weakness
2.1.2.2 Measurable outcomes for lower extremity muscular weakness
2.1.3.1 Balance deficits
2.1.3.2 Measurable outcomes for balance deficits
2.1.4.1 Gait deficits
2.1.4.2 Measurable outcomes for gait deficits
2.1.4.3 Summary of risk factors for falling and outcome measures
3.0 Effectiveness of fall preventative interventions
4.0 Types of fall prevention interventions
4.1.1 Exercise interventions for the prevention of falls
5.0 Introduction to dance
5.1.1 Critical review of dance interventions for prevention of falls
5.1.2 Dance studies that measured muscular endurance of the lower extremity
5.1.2.1 Summary of dance studies measuring muscular endurance of the lower extremity
5.1.3 Dance studies that measured balance
5.1.3.1 Single leg stance
5.1.3.2 Berg balance scale
5.1.3.3 Sway
5.1.3.4 Summary of dance studies measuring balance
5.1.4 Dance studies that measured gait
5.1.4.1 Timed up and go
5.1.4.2 Four square step test
5.1.4.3 Stepping motor response
5.1.4.4 Summary of dance studies measuring gait
6.0 Summary of literature review
7.0 Background to research project between Unitec New Zealand and Dance Aotearoa NZ
8.0 References
SECTION TWO: Manuscript

Title
Abstract

1.0 Introduction

2.0 Methods
  2.1 Study setting and participants
  2.1.1 Study design
  2.1.2 Study design
  2.1.2.1 Cohort 1 DANZ mobility dance
  2.1.2.2 Cohort 2 Selwyn Folk dance
  2.1.3 Outcome measures and procedures
  2.1.3.1 30 s Seated chair stand
  2.1.3.2 Single leg stance
  2.1.3.3 Four square step test
  2.1.3.4 Static sway
  2.1.4 Statistical methods
  2.1.4.1 Data analysis

3.0 Results

4.0 Discussion
  4.1 Overview
  4.1.2 Lower extremity muscular endurance
  4.1.2.1 Lower extremity muscular endurance: DANZ versus Selwyn
  4.1.2.2 Lower extremity muscular endurance: compared to similar studies
  4.1.3 Single leg stance
  4.1.4 Multidirectional dynamic gait and balance
  4.1.5 Sway
  4.1.5.1 Comparisons to previous studies
  4.1.6 Study limitations

5.0 Conclusion

6.0 Conflict of interest

7.0 References

SECTION THREE: Appendices

Appendix A: Physical outcome measures
Appendix B: Supplementary results table
Appendix C: Ethic approval
Appendix D: Information sheet for participants
Appendix E: Participant consent form
Appendix F: Enrolment form
Appendix G: Medical history questionnaire
Glossary

3D exercise – 3D (three dimensions) requires movement in three dimensions; flexion/extension abduction/adduction, and rotation of limbs, torso and neck and include dance, Tai Chi and qi gong.

Balance – Requires postural control and “the complex integration of sensory information regarding the position of the body relative to the surroundings and the ability to generate appropriate motor responses to control body movement” (Sturnieks, St George, & Lord, 2008). Dynamic balance is where the base of support and the centre of mass move concurrently. Static balance involves the centre of mass moving with the base of support remaining stationary (Granacher, Bridenbaugh, Muehlbauer, Wehrle & Kressig, 2011).

Dance – is a type of art that generally involves movement of the body, often rhythmic and to music.

Dance Mobility – A program of dance based on ballet and contemporary dance exercises designed to build balance, coordination and strength to enhance mobility for over 65-year olds. Each class concludes with an optional half-hour social interaction session over a cup of tea and a biscuit. For more information, see [http://www.danz.org.nz/workshops.php](http://www.danz.org.nz/workshops.php)

Exercise – Is an activity requiring physical effort, carried out to sustain or improve health and fitness

Fall – Defined by the Prevention of Falls Network Europe (ProFaNE) working group as “an unexpected event in which the participants come to rest on the ground, floor, or lower level” (Lamb, Jorstad-Stein, Hauer, & Becker, 2005).

Folk Dancing – A type of dancing based on traditional cultural dances from around the world. In this study, music and dance movements were drawn from traditional folk dance, including Yugoslav, Shegra, St George Cross, Chinese, Greek and Tennessee Walk.

Fragility – The quality of being easily broken or damaged

Physical activity – Physical exercise is any bodily activity that enhances or maintains physical fitness and overall health and wellness.

ProFaNE – Prevention of Falls Network Europe. A collaborative project set up to reduce “the burden of fall injury in older people through excellence in research and promotion of best practice” (Lamb et al., 2005).

Tai Chi – A Chinese system of slow meditative physical exercise designed for relaxation and balance and health
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 s SCS</td>
<td>30 second seated chair stand</td>
</tr>
<tr>
<td>3D classes</td>
<td>Three dimensional movement classes: Tai Chi, dance, qi gong</td>
</tr>
<tr>
<td>BBS</td>
<td>Berg balance scale</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence interval</td>
</tr>
<tr>
<td>d</td>
<td>Effect size</td>
</tr>
<tr>
<td>DANZ</td>
<td>Dance Aotearoa New Zealand</td>
</tr>
<tr>
<td>EXDASE</td>
<td>Exercise Dance for Seniors</td>
</tr>
<tr>
<td>FSST</td>
<td>Four square step test</td>
</tr>
<tr>
<td>ICC</td>
<td>Intra-class correlation coefficient</td>
</tr>
<tr>
<td>IRR</td>
<td>Incident rate ratio</td>
</tr>
<tr>
<td>IQR</td>
<td>Interquartile range</td>
</tr>
<tr>
<td>NZD</td>
<td>New Zealand dollar</td>
</tr>
<tr>
<td>n</td>
<td>Number of participants in a study</td>
</tr>
<tr>
<td>p</td>
<td>Probability-value</td>
</tr>
<tr>
<td>ProFaNE</td>
<td>Prevention of Falls of Network Europe</td>
</tr>
<tr>
<td>SLS</td>
<td>Single leg stance</td>
</tr>
<tr>
<td>TUG</td>
<td>Timed up and go</td>
</tr>
</tbody>
</table>
Introduction to Thesis

The number of older adults in New Zealand and throughout the world has been steadily rising in recent years and is forecast to increase in the years ahead (Hopkins, 1990; Statistics New Zealand, 2009). Falls are the leading cause of injury and injury-related deaths in adults over the age of 65 (Myers, Young, & Langlois, 1996; Robertson, 2010). Falls are associated with a large socioeconomic burden for government health agencies (and individuals) which has prompted investigations into fall preventative strategies to combat the growing falls problem (Robertson & Campbell, 2008). The New Zealand Ministry of Health reports that treatment for older adults from fall-related injuries account for a substantial portion of total health expenditure. In the last two years the Ministry of Health terminated funding on fall preventative exercise interventions due to the government’s perception of financial constraints (Robertson, Campbell, Gardner, & Devlin, 2002). Therefore, there is a reduction in accessibility for New Zealand older adults to fall preventative interventions.

The aims of this thesis were to 1) review the existing literature in relation to effectiveness of current interventions used in the prevention of falls, focusing on whether dance as an exercise intervention may reduce risk factors for falling in older adults; and 2) to investigate the extent to which dance may reduce risk factors for falling in the older adult New Zealand population. An independent study was conducted in parallel to the current study which investigated the psychosocial effects of dance and is reported elsewhere (Russell, 2013).

The thesis is divided into three main sections, literature review, manuscript and appendices. The literature review introduces the epidemiology and socioeconomic impact of falls within the older adult population and provides a rationale for investigating physical risk factors associated with falling. Interventions that have been used for the prevention of falls are mentioned with a focus on exercise based interventions. A rationale is developed for why dance classes may be an appropriate fall preventative exercise for older adults. This is followed by a review and analysis of studies investigating the effects of dance with the intention to prevent falls in adults over the age of 65.

The review leads into the manuscript in the second section which has been formatted to conform to the Archives of Gerontology and Geriatrics journal requirements. The manuscript outlines the methods used and reports findings of a double-cohort pilot study which investigated the extent to which dance may reduce risk factors for falling; muscular endurance of the lower extremity, balance and gait, in adults over the age of 65.

Ethics documentation, research questionnaires, and additional data not reported in the manuscript are presented in the Appendices.
SECTION ONE: Literature Review
Literature Review

1.0 Introduction
1.1.1 Epidemiology and socioeconomic implications of falls in the older adults
1.1.2 Fall prevention in the New Zealand context
1.1.3 Fall-related injuries
1.1.4 Conditions that can predispose older adults to injuries

2.0 Risk factors for falling in older adults
2.1.1 Direct versus indirect outcome measures
2.1.2 Risk factors for falling
2.1.2.1 Lower extremity muscular weakness
2.1.2.2 Measurable outcomes for lower extremity muscular weakness
2.1.3.1 Balance deficits
2.1.3.2 Measurable outcomes for balance deficits
2.1.4.1 Gait deficits
2.1.4.2 Measurable outcomes for gait deficits
2.1.4.3 Summary of risk factors for falling and outcome measures

3.0 Effectiveness of fall preventative interventions

4.0 Types of fall prevention
4.1.1 Exercise interventions for the prevention of falls

5.0 Introduction to dance
5.1.1 Critical review of fall preventative dance interventions
5.1.2 Dance studies that measured muscular endurance of the lower extremity
5.1.2.1 Summary of muscular endurance of the lower extremity
5.1.3 Dance studies that measured balance
5.1.3.1 Single leg stance
5.1.3.2 Berg balance scale
5.1.3.3 Sway
5.1.3.4 Summary of dance studies measuring balance
5.1.4 Dance studies that measured gait
5.1.4.1 Timed up and go
5.1.4.2 Four square step test
5.1.4.3 Stepping motor response
5.1.4.4 Summary of dance studies measuring gait

6.0 Summary of literature review

7.0 Background to research project between Unitec New Zealand and Dance Aotearoa

8.0 References
1.0 Introduction

The population in New Zealand, like other developed nations is rapidly ageing. According to Statistics New Zealand (2009), the number of adults over the age of 65, referred to as ‘older adults’ (Campbell & Robertson, 2010) will reach one million in the early 2020s. Falls are the leading cause of injury and injury-related deaths in adults over the age of 65, with a third of older adults experiencing a fall every year (Myers et al., 1996; Robertson & Campbell, 2008). Older adults not only fall more often than younger adults during normal day to day activities, but the injuries they sustain are more severe due to their fragility (Myers et al., 1996). The socioeconomic implications associated with the rising number of older adults and fall-related injuries, have prompted government health agencies to assess people at high risk of falling and provide fall preventative interventions to combat the growing falls problem (Robertson & Campbell, 2008). However, despite the growing fall-related health expenditure, the New Zealand Ministry of Health has terminated nationwide funding on fall prevention exercise interventions available to the public, the Otago Exercise Program and Modified Tai Chi classes, leaving just Vitamin D supplementation as the only funded fall prevention initiative (Robertson & Campbell, 2008; Todd, 2010). Therefore, investigations of fall preventative interventions may reveal other alternatives that could be used to effectively prevent falls in the aging New Zealand population.

This literature review specifically focuses on the fall preventative benefits of dancing in older adults. The first section highlights background information on falls in context to the New Zealand older adult population. The second section describes outcomes that are used to measure particular risk factors for falling, and the third section, the main body of the literature review, investigates the effectiveness of interventions used in the prevention of falls, and fall-related injuries, with a focus on exercise interventions (predominately dance).

1.1.1 Epidemiology and socioeconomic implications of falls in older adults

In the United States, the population of adults over the age of 65 grew from 2 million (3%), to 25 million (11.3%), between 1880 - 1980 (Hopkins, 1990). Like the United States and other developed countries, the population of adults over the age of 65 in New Zealand is also increasing. The projected number of older adults is estimated to increase from 550,000 in 2009 (13% of total population), to over 1 million (20%) by the early 2020’s (Statistics New Zealand, 2009).

A collaborative group, the Prevention of Falls Network Europe (ProFaNE) has defined a fall as “an unexpected event in which the participant comes to rest on the ground, floor, or lower level” (Lamb et al., 2005). A third of older adults experience a fall each year (Robertson & Campbell, 2008) and 50% of those fall multiple times (Costello & Dedelstein, 2008). Given the leading cause of injury and
injury-related deaths in older adults are falls, and that the number of older adults is rising, it is anticipated that the incidence of falls, and related-injuries and deaths, will also increase (Campbell & Robertson, 2010; Rubenstein & Josephson, 2002).

Older adults not only fall more often than younger adults, they also injure themselves more often with more severe injuries due to fragility (Myers et al., 1996), and therefore technically falling is not costly in itself, but rather it is the subsequent treatment and rehabilitation from fall-related injuries that incurs direct (e.g. hospital care) and indirect costs (e.g. quality of life including to family). Interventions that help to prevent falls are likely to be more cost effective than improving treatment of fall-related injuries and this rationale has underpinned research in this field (Holmerova et al., 2010; Robertson & Campbell, 2008).

1.1.2 Fall prevention in the New Zealand context

In 2008, the Ministry of Health funded three fall preventative initiatives nationwide; vitamin D supplementation, Modified Tai Chi classes, and the Otago Exercise Program. The Vitamin D intervention involved supplying older adult populations at high risk of falling with the supplement (Robertson & Campbell, 2008). Modified Tai Chi classes were performed in groups at community halls and fitness centres, and the Otago Exercise Program is a strength and balance retraining program delivered to individuals in their own home by a physiotherapist or similar provider (Robertson & Campbell, 2008). In the same year, the Ministry of Health in conjunction with Accident Compensation Corporation compiled a review to optimise their fall prevention approach for older adults (Robertson & Campbell, 2008). The review recommended that a wide variety of interventions were needed since current interventions were simply not cost effective, physically suitable, or those available did not cater sufficiently for the highly selective exercise choices of the older adult population (Robertson & Campbell, 2008).

The review by the Ministry of Health and Accident Compensation Corporation concluded the Otago Exercise Program and Modified Tai Chi classes were clinically effective at reducing risk factors for falling, however, not at a financially cost effective rate. The direct costs to treat a fall in 2008 NZD (New Zealand dollar) prices was estimated to be $668. The Otago Exercise Program cost NZD $549,000 to deliver the program per/1000 participants, per year and theoretically only saved NZD $71,182 in prevented falls (32% reduction in falls). Likewise Modified Tai Chi classes cost $303,000 to deliver the program per/1000 participants, per year and theoretically saved less than $29,000 in prevented falls (13% reduction in falls). Therefore, both interventions are expensive to implement compared to the return for investment. By comparison, vitamin D costs NZ $7.76 per person for one year’s supply and reduces falls slightly more effectively than Modified Tai Chi (Robertson &
It was suggested the cost effectiveness of funding vitamin D supplementation, may be why the Ministry of Health terminated funding of the Otago Exercise Program and Modified Tai Chi classes and continued with vitamin D supplementation (M. C. Robertson, personal communication, June 08, 2011).

The financial importance of minimising falls is clear from previous fall expenses. Fall-related injuries in New Zealand for people over 80 years of age cost NZD $38.8 million in the 2006/07 fiscal year. From this total 80% cost less than NZD $700 per fall with 2.3% costing more than NZD $10,000. Higher per fall costs were associated with fractures requiring surgical interventions (Robertson & Campbell, 2008). The most common fractures that require hospitalisation are wrist, hand trunk and hip fractures, the latter being more severe and expensive to treat (Robertson & Campbell, 2008; Wong et al., 2009).

1.1.3 Fall-related injuries

The physical direction in which a person falls to the ground can influence impact location and, consequently, injury outcomes. Falling backwards has the highest risk factor for wrist and vertebral fractures, while sideways falling has the highest risk of fracturing a hip (Wong et al., 2009). Therefore, assessing lateral stepping ability, which is not often performed in activities of daily living, may help identify participants at high risk of falling sideways and subsequent hip fractures (Wong et al., 2009).

Approximately 25% of older adults who fracture a hip will move to a nursing home (mostly due to mobility disabilities) and 20% will die within a year from a number of multi-factorial psychosocial factors (Rubenstein & Josephson, 2002). Older adults who reside in nursing homes fall 30% more often than older adults living in non-nursing residences (Robertson et al., 2002). Children and athletes fall more often than older adults, yet older adults are more vulnerable to severe injuries that lead to increased mortality and morbidity rates (Rubenstein, Kenny, Koval, Martin, & Tinetti, 2001). Many medical conditions that are more prevalent in the older adult population, compared to younger adults, can further predispose older adults to be more vulnerable to fall-related injuries (Costello & Dedelstein, 2008; Rubenstein et al., 2001).

1.1.4 Conditions that can predispose older adults to injuries

As the nervous system plays a critical role in maintaining balance, it is not surprising that conditions that impair the nervous system such as Parkinson’s disease, multiple sclerosis or Alzheimer’s disease, can negatively influence balance and are often progressive and debilitating
The prescribed medications to control the symptoms of some neurological conditions can also negatively influence balance, especially when taking four or more medications (Campbell, Robertson, Gardner, Norton, & Buchner, 1999; Costello & Dedelstein, 2008; Earhart, 2009; Hackney & Earhart, 2009; Pickering et al., 2007).

2.0 Risk factors for falling in older adults

2.1.1 Direct versus indirect outcome measures

The effectiveness of fall prevention interventions are measured using two distinctly different methods. One method is to directly measure the number of falls participants sustained pre-and post-intervention. This is usually undertaken using fall diaries (Gillespie et al., 2010). The other indirect method assesses the risk of falling by measuring changes in risk factors for falling (Howe, Rochester, Jackson, Banks, & Blair, 2008; Rubenstein et al., 2001). Although direct methods are preferable to indirect methods for validity reasons, practical problems are encountered with older adult recall. Also prospective studies with clinical outcome measures (actual falls or injuries) are more time consuming and, therefore, more expensive, which may be why the majority of fall preventative research that has been undertaken has used indirect methods. This indirect method has been strengthened by several reviews which conclude there are specific influential risk factors for falling.

2.1.2 Risk factors for falling

Risk factors for falling have been categorised into internal physical risk factors (e.g. lower extremity muscle strength, balance disorders, cognitive impairment, failing eyesight), external risk factors (e.g. side effects of prescription medicines) and environmental risk factors (e.g. poor lighting, loose carpets, sharp edged furniture) (Rubenstein et al., 2001). Several reviews and individual studies agree that the most influential risk factors for falling, from most influential to least, include muscular weakness, balance deficits, gait deficits, use of assisting device, history of falls, visual deficits, arthritis, impaired activities of daily living, depression, cognitive impairment and being over 80 years of age (Lipsitz, Jonsson, Kelley, & Koestner, 1991; Rubenstein & Josephson, 2002; Rubenstein et al., 2001; Tinetti et al., 1994). A combination of any of these risk factors dramatically compounds an individual’s chance of falling. Individuals with one risk factor are at 27% increased
risk of falling, compared to 78% with four or more risk factors (Tinetti, Williams, & Mayewski, 1986). The presence of multiple risk factors is the most common scenario. The current review will focus on the most influential physical risk factors for falling. The review by Rubenstein et al., (2001) concluded the top internal physical risk factors for falling with an odds ratios between 2.9 – 4.4 were: 1) muscular weakness of the lower extremity; 2) balance deficits; and 3) gait deficits, with other risk factors having odds ratios less than 2.3 and therefore less influence on falls (Rubenstein et al., 2001). Identifying older adults who are at the highest risk of falling is important as this population stands to benefit the most from fall prevention interventions (Robertson & Campbell, 2008; Rubenstein et al., 2001).

2.1.2.1 Lower extremity muscular weakness

Although muscle atrophy and associated loss of muscle strength are part of the natural aging process, it is known that muscle mass and endurance decline significantly from disease (mostly nutritional related) and inactivity (Rubenstein & Josephson, 2002). Between 0.5 - 1.0% of muscle mass declines annually over the age of 60 years and is associated with reductions in strength and endurance, most notably in the lower extremities (Morse et al., 2005; Wolfson, Judge, Whipple, & King, 1995). A reduction in muscle mass and muscular endurance can predispose older adults to fall and sustain fall-related injuries in two distinct ways. First, a reduction in lower extremity muscular endurance can impede an individual’s mobility, gait and simple activities of daily living (Wolfson et al., 1995), increasing their risk of falling (Young, Weeks, & Beck, 2007). Second, skeletal muscle bulk has a ‘shock absorbing’ function, which acts to cushion internal organs and skeletal structures and when muscles atrophy, this reduces the protective function, exposing older adults to impact injuries. Both muscle and bone are highly adaptive to training stimuli, and a reduction in muscle mass and weakness can be offset, if not reversed, with simple physical activity (along with adequate nutrition) in as little as one bout per week (Holmerova et al., 2010; Wolfson et al., 1995; Young et al., 2007).

2.1.2.2 Measurable outcomes for lower extremity muscular weakness

A common method of measuring muscular endurance is with a weighted isolated leg extension with the prime mover being the quadriceps muscles (Oldham & Howe, 1995). However, this movement is not an action performed in most activities of daily living, and therefore may be termed as a ‘non-functional’ outcome measure. An alternative to the isolated leg extension measure is a compound ‘30 s seated chair stand’ (30 s SCS) which recruits the gluteal muscles, hamstrings, quadriceps and leg flexors and extensors synergistically. Participants are required to sit and stand from a chair as
many times as possible in 30 s, measuring muscular endurance of the lower extremity with a movement performed often in activities of daily living (standing from a seated position) and therefore may be termed as a ‘functional’ outcome (Osness et al., 1996; Rikli & Jones, 1999). The outcome has been shown to have good test-retest reliability (ICC > 0.90) (Miotto, Chodzko-Zajko, Reich, & Supler, 1999). However, Jones et al., (1999) have identified improved performance across the sessions probably as a result of a learning effect from repeating the outcome (Jones, Rikli, & Beam, 1999). Therefore, at least one practise run is recommended, followed by three individual trials, averaging the three scores (Miotto et al., 1999).

2.1.3.1 Balance deficits

Static balance is challenged when individuals are stationary (such as during upright standing), while dynamic balance is challenged when individuals are in motion (such as during gait). Falls occur 85% of the time in dynamic environments when individuals are in motion, therefore dynamic balance plays a pivotal role in falls (Nnodim et al., 2006). Balance involves integrative processes of visual, vestibular and proprioceptive sensory input to maintain balance (Mientjes & Frank, 1999). A larger number of sensory inputs occur during dynamic balance, compared with static balance, resulting in a higher number of motor commands to maintain equilibrium (Fryer, Mudge, & McLaughlin, 2002; Nnodim et al., 2006). This process requires participants to share attention between different inputs, which increases the chance of falling from divided attention (Caby, Kieffer, De Saint Hubert, Cremer, & Macq, 2011).

Although only 15% of falls occur from static postures, these postures serve a crucial function, enabling individuals to maintain equilibrium while sitting or standing (Rubenstein & Josephson, 2002). Participants with poor static balance are at a higher risk of falling during both static and dynamic postures. Without good static balance, simple postures may be challenging to maintain. Ideally, when assessing balance, both static and dynamic balance should be measured (Campbell & Robertson, 2010; Nnodim et al., 2006).

2.1.3.2 Measurable outcomes for balance deficits

The most commonly used measurable outcomes to assess balance are the Berg balance scale (BBS) and the single leg stance (SLS), and sway. The BBS is an assessment for identifying risk of falling and has been used extensively in the hospital setting (Cowley & Kerr, 2003; Gillespie et al., 2010). The protocol consists of 14 tasks: with each task assigned a score between 0 and 4, taking into account quality of movement and time taken to complete the task. The BBS has been shown to have good inter-rater and intra-rater reliability (ICCs > 0.90) (Berg, Maki, Williams, Holliday, & Wood-
Dauphinee, 1992), although more recently ceiling effects have been reported in some higher functioning populations (Cowley & Kerr, 2003; Leddy, Crowner, & Earhart, 2011; Rubenstein et al., 2001) and it has been further criticised for the amount of subjective practitioner interpretation in the scoring system (Caby et al., 2011).

A single leg stance (SLS) task that requires participants to stand on one leg has been shown to have acceptable values of reliability (ICC = 0.74) over an average of three timed trials (Muir, Berg, Chesworth, Klar, & Speechley, 2010). The SLS is a timed task that requires participants to stand on one foot until they lose their balance or they reach a cut-off time (Cowley & Kerr, 2003). The SLS outcome is inexpensive and simple to implement and instruct to unfamiliar participants (Miotto et al., 1999).

A further measure of balance is ‘postural sway’. During upright stance, the centre of body mass oscillates over the base of support in response to internal and external perturbations (Winter, 1995). This oscillation is a natural adjusting process and can be measured with an electronic sensory sway-plate in different static or dynamic postures however, the ideal level of sway in a healthy person has not yet been established (Mientjes & Frank, 1999). Sway-plates are becoming more popular as a measuring tool yet have not been used widely in fall preventative research. In the symptomatic population postural sway has been observed to increase with reduced orthostatic control and may therefore be undesirable, for example, in vestibular organ dysfunction or Alzheimer’s or central nervous system diseases (Claydon & Hainsworth, 2005; Horak et al., 1989).

### 2.1.4.1 Gait deficits

An effective gait cycle is the ability of an individual to walk with an appropriate speed, rhythm and length of step during a normal heel strike, mid-stance and toe-off sequence (Jamshidi et al., 2009). Gait requires a complex integration of visual, vestibular and proprioceptive sensory input (Fryer et al., 2002) and therefore adequate balance is essential to maintain normal gait. Gait deficits can lead to mobility disability in older adults and contribute towards higher rates of morbidity and mortality (Brach et al., 2011). When gait is impaired, the risk of falling is known to increase (Rubenstein et al., 2001).

Gait assessments have classically been performed in single planes, under well-lit ideal conditions, on even surfaces and with limited distractions (Brach et al., 2011). These conditions may not adequately represent environments in which gait occurs in everyday life (Bandinelli, Pozzi, & Lauretani, 2006). Consequently, gait assessments have been developed which include multi-plane, multi-gait tasks, such as stepping in an anterior and lateral direction or standing from a sitting
position and turning (Brach et al., 2011). Another modification to gait measures has investigated lower extremity stepping reaction speed to evaluate how quickly an individual may respond if they slip and thus, potentially prevent a fall (Nnodim et al., 2006; Wong et al., 2009; Young et al., 2007).

2.1.4.2 Measurable outcomes for gait deficits

Examples of gait outcomes that require shared attention and gait speed are the “timed up and go” (TUG) outcome (Podsiadlo & Richardson, 1991) and the four square step test (FSST). The TUG requires participants to stand from a sitting position, walk around a cone three meters in front of the chair and return to the original sitting position, mostly challenging multidirectional gait and balance (Whitney, Marchetti, Morris, & Sparto, 2007). This protocol has also been modified (‘modified TUG test’) with different placements of the cones for increased safety (Cowley & Kerr, 2003). The FSST challenges multidirectional dynamic gait and balance, similarly to the TUG outcome. It incorporates anterior, posterior and lateral stepping at speed, in an anticlockwise and clockwise direction, which are movements that are typically difficult for people with balance disorders (Whitney et al., 2007). The outcome provides a quantitative measure of the ability to quickly change directions while lifting the feet off the ground and placing them back in a multidirectional fashion. The FSST has been shown to be a reliable and valid measure to identify older adults with balance deficits who are at high risk of falling (Whitney et al., 2007).

2.1.4.3 Summary of risk factors for falling and outcome measures

In summary, physical risk factors for falling have been established by several reviews and there is general consensus that muscular endurance of the lower extremity, along with balance and gait deficits, are the most influential physical risk factors for falling (Lipsitz et al., 1991; Rubenstein et al., 2001; Tinetti et al., 1994). With clear risk factors identified, indirect outcome measures are one way to assess possible fall preventative benefits from interventions. However, reliable validated measurable outcomes need to be used to measure changes in risk factors for falling. For each risk factor (muscular endurance, balance and gait) one or more commonly used ‘functional’ outcome measure(s) has been shown to have good reliability, along with several other measures that lack reliability.
3.0 Effectiveness of fall preventative interventions

A literature search was conducted to identify what interventions have been used in the prevention of falls and fall-related injuries within the older adult population. The search had a primary focus on exercise interventions that may appeal and be physically suitable for the older adult population, in particular different styles of dance. Due to many similarities between dance and Tai Chi (Keogh et al., 2012), Tai Chi was included as a form of ‘dance’ in this review. The literature search was retrieved from several electronic databases through EBSO HOST, Medline, Sports Discus, Cochrane Databases and Scopus all in English. The key words searched were; prevention of falls, balance, dance, exercise, elderly and older adults.

4.0 Types of fall preventative interventions

Many interventions, both exercise and non-exercise-based, have been used in the prevention of falls. Non-exercise interventions include vitamin D supplementation, hormone replacement therapy, hip protectors, safety flooring, home safety assessment and cataract surgery (Robertson & Campbell, 2008). Exercise interventions, compared to non-exercise interventions, can be implemented without medically trained specialists, with few resources needed and can therefore be relatively inexpensive (Robertson & Campbell, 2008). A further advantage is that exercise also reduces the incidence of health complications such as cardiovascular disease, obesity, stroke, osteoporosis and fractures (Holmerova et al., 2010; Robertson & Campbell, 2008; Shigematsu et al., 2002; Young et al., 2007).

4.1.1 Exercise interventions for the prevention of falls

In 2005 the Prevention of Falls Network Europe (ProFaNE) established a characterisation of different fall preventative exercises including a) gait, balance and functional training; b) strength/resistance training; c) 3D exercise (which is referred to ‘3D’ as it requires participants to move their bodies in three dimensions (flexion/extension, abduction/adduction, rotation) and includes dancing, Tai Chi and qi gong); d) flexibility training (yoga and stretching); e) general physical activity (walking, cycling); f) endurance exercise; and g) multiple intervention types (combination of any categories) (Lamb et al., 2005). Several later reviews further evaluated the fall preventative benefits of each modality (Costello & Dedelstein, 2008; Gillespie et al., 2010; Howe et al., 2008). The reviews by Howe et al., (2008) and Gillespie et al., (2010) applied the same exercise classifications to ProFaNE.
The reviews showed that exercise interventions combining two or more modalities achieved larger effects than any single exercise modality (Gillespie et al., 2010; Howe et al., 2008), yet the authors did not analyse which combination of modalities was most effective. After an analysis of the single modality findings, both reviews (Gillespie et al., 2010; Howe et al., 2008) showed two exercise modalities that significantly reduced the risk of falling, more effectively than any other modality were, a) gait, balance, functional training modalities, and b) 3D exercise modalities. These conclusions were drawn from 4051 participants over 26 studies making such claims hard to dispute. It is of interest that these two exercise modalities run many physical similarities to one another. For example performing a squat, balancing on one leg, stepping in a multidirectional gait are common movements performed in both gait, balance, functional training modalities as well as 3D exercise modalities. Therefore, dance may be effective in reducing risk factors for falling in older adults.

5.0 Introduction to dance

The origins of dance are relatively unknown as dance does not leave behind many physical artefacts that last over a millennium (Cayou, 2012). Archaeologists have found evidence of dance from Egyptian tomb paintings dating back as far as 3300 BC (Murrock & Gary, 2008). African tribes traditionally dance for specific times of need such as births, puberty, marriage, death or war (Cayou, 2012). In the 21st century dance is still an art form and an expression of cultural identity (Murrock & Gary, 2008) in most human groups. Tai Chi on the other hand has identifiable origins which trace back to the 16th century in China where it initially was utilised in the East and has grown in popularity in the west, as well as within the older adult communities (Li, Xu, & Hing, 2009). As an exercise form, Tai Chi has many similarities with dance in that it is generally performed in an upright posture with substantial periods of unilateral footing, transferring the line of gravity outside the base of support (Keogh, Kilding, Pidgeon, Ashley, & Gillis, 2009; Nnodim et al., 2006). Tai Chi can involve high ground reaction forces and joint torques that can result in relatively high heart rates (68%-90% of age-predicted maximum heart rate) in young and old (Keogh et al., 2009). Therefore, in the current review, Tai Chi is henceforth encompassed in the term ‘dance’.

Dance-based exercise is appealing and beneficial to a wide variety of ages. Much research supports the notion that dance primarily improves balance and reduces physical risk factors for falling. However, dance has also been shown to improve cognitive functions such as cognitive processing, 3D spatial awareness and progressive memory pattern recognition (Keogh et al., 2009) while having psychological and psychosocial health benefits (Shigematsu et al., 2002; Sofianidis,
Hatzitaki, Douka, & Grouios, 2009). Practically, dance can be modified to suit different physical capabilities (Keogh et al., 2009) and can be performed individually, with a partner or in a group. The social aspects of dance encourage individuals to exercise more often and more consistently compared with solo exercisers and is more cost effective to implement (Deforche & De Bourdeaudhuij, 2000).

5.1.1 Critical review of fall preventive dance interventions

In total 17 individual dance studies were selected for review (Table 1). The 17 studies were selected if they included participants that were over >65 years of age, implemented dance as a fall preventative intervention of any duration, measured falls or at least one influential physical risk factor of falling, was written in the English language and published in a peer reviewed journal. Studies that were published up until August 2012 were included in this review. From the 17 studies, 12 studies compared a dance intervention to a control group, with 11 of those studies using random selection. The remaining five studies recorded changes in variables within participants pre-to post-intervention.

The majority of dance studies (10 out of 17) measured muscular endurance of the lower extremity, balance and gait (Eyigor, Karapolat, Durmaz, Ibisoglu, & Cakir, 2008; Holmerova et al., 2010; Hopkins, 1990; Hui, Chui, & Woo, 2009; Keogh et al., 2009; Lin, McClear, & Tabourne, 2008; Nnodim et al., 2006; Robertson et al., 2002; Shigematsu et al., 2002; Young et al., 2007), with the remaining studies (7 out of 17) measuring one or two influential risk factors for falling (Table 1).

From the 10 studies that measured all three risk factor variables, six studies observed a statistically significant improvement (p<0.05) across all three risk factors compared to controls (Eyigor et al., 2008; Holmerova et al., 2010; Hopkins, 1990; Nnodim et al., 2006; Robertson et al., 2002; Young et al., 2007). Three studies observed similar significant results (p<0.05) compared to controls for two risk factor variables (Hui et al., 2009; Lin et al., 2008; Shigematsu et al., 2002) and one study observed a statistically significant result (p<0.05) in one risk factor (Keogh, Kilding, Pidgeon, Ashley, & Gillis, 2012).

The Keogh et al., (2012) study was designed to investigate whether a 12-week mobility dance class for older adults that participated once or twice weekly would reduce risk factors for falling more effectively. No statistically significant changes in muscular endurance (measured via 30 s SCS) and balance (measured via TUG) were found, yet a large (d=0.6), significant improvement in the gait test (measure via FSST) was demonstrated. This result was surprising as it was not consistent compared to the majority of dance studies reviewed. Further, dance challenges balance and lower extremity muscular endurance and therefore improvements were expected to be of similar
magnitude to the improvements observed in the gait outcome. A potential reason why the results in the Keogh et al., (2012) study were not consistent with the wider literature may be from the participants performing better at baseline with ~5 repetitions more for the 30 s SCS outcome and 1.5 s to 4 s better in the TUG test, when compared with participants in the Holmerova et al., (2010) and Young et al., (2007) studies. However the results from the Keogh et al., (2012) study may show that the dance intervention implemented may not reduce risk factors of falling. Therefore, since participants already possessed quite high levels of muscular endurance and balance, there was potentially less room for improvement. The results from the Keogh et al., (2012) study showed that dancing may reduce gait deficits without affecting other risk factors; however, the majority of dance studies observed changes in balance and muscular endurance in addition to gait. The following section will cover the effectiveness of different dance studies categorised by risk factor variables measured, including lower extremity muscular endurance, balance and gait.
<table>
<thead>
<tr>
<th>Author</th>
<th>Location, Journal</th>
<th>No and mean age of participants</th>
<th>Participant, description</th>
<th>Intervention type</th>
<th>Intervention duration</th>
<th>Control group</th>
<th>Effect size *</th>
<th>Effect size **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpert et al.</td>
<td>USA, Journal of the American Academy of Nurse Practitioners</td>
<td>(n=13) mean 68</td>
<td>Healthy, community-dwelling</td>
<td>Modified jazz dance: &quot;choreographed traditional ballet movements&quot;</td>
<td>15 wks (x 1 d/wk)</td>
<td>No control</td>
<td>SOT test (Y)</td>
<td>1.1**</td>
</tr>
<tr>
<td>Eyigor et al.</td>
<td>Turkey, Archives Of Gerontology And Geriatrics</td>
<td>(n=37) mean 72</td>
<td>Rehabilitation unit, &quot;healthy adult elderly&quot;</td>
<td>Turkish folkloric dance-based exercise</td>
<td>8 wks (60 min x 3 d/wk plus walking 30 min x 2 d/wk)</td>
<td>Usual physical activity (n=18) mean 71</td>
<td>5 repetition SCS (Y*)</td>
<td>1.0**</td>
</tr>
<tr>
<td>Federici et al.</td>
<td>Italy, Aging Clinical and Experimental Research</td>
<td>(n=20) mean 62</td>
<td>Healthy community-dwelling sedentary elderly</td>
<td>Caribbean dance-based Puertorican salsa classes</td>
<td>12 weeks (wk1-2 30-35 min, wk3-12 45-60 min, x 2 d/wk)</td>
<td>Usual physical activities (n=20) mean 63</td>
<td>Seated Tinetti test (N)</td>
<td>0.0**</td>
</tr>
<tr>
<td>Hong et al.</td>
<td>Hong Kong, British Journal of Sports Medicine</td>
<td>(n=58) mean 67</td>
<td>Healthy male Tai Chi Chuan instructors</td>
<td>Previous experience in Tai Chi Chuan</td>
<td>No duration</td>
<td>Sedentary males (n=30) mean 66,</td>
<td>Resting heart rate (Y*)</td>
<td>¥</td>
</tr>
<tr>
<td>Hui et al.</td>
<td>Hong Kong, Archives of Gerontology &amp; Geriatrics</td>
<td>(n=111) mean 68</td>
<td>Healthy community-dwelling residents</td>
<td>Low impact aerobic dance: consisting of &quot;cross steps and cha-cha steps&quot;</td>
<td>12 wks (50 mins x 2 d/wk for 6 wks then 60 mins x 2 d/wk for 6 wks)</td>
<td>Usual physical activities (n=45) mean 69</td>
<td>30s SCS (Y*)</td>
<td>0.8**</td>
</tr>
</tbody>
</table>

Table 1: Characteristics of dancing studies for older adults that measured at least one physical risk factor of falling
<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Country</th>
<th>Journal</th>
<th>Participants</th>
<th>Setting</th>
<th>Intervention Details</th>
<th>Baseline Physical Activities</th>
<th>Follow-Up</th>
<th>Statistic(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keogh et al. (2012)</td>
<td>NZ</td>
<td>European Journal of Sports and Exercise Science</td>
<td>n=45</td>
<td>Healthy retirement-dwelling residents</td>
<td>Modern/contemporary dance: Movements based on a theme/imaginative stimulus.</td>
<td>12 wks (25-50 min per session x 1 d/wk or x 2 d/wk)</td>
<td>Usual physical activities (n=13)</td>
<td>Once weekly 30s SCS (N) 0.1** FSST (Y*) 0.6** TUG (N) 0.0** Twice weekly 30s SCS (N) 0.1** FSST (Y) 0.3** TUG (N)</td>
</tr>
<tr>
<td>Li et al. (2009)</td>
<td>China</td>
<td>Journal of Biomechanic</td>
<td>n=40</td>
<td>Healthy community-dwelling &lt; 60 year olds</td>
<td>Tai Chi</td>
<td>6 wks (60 min x 4 d/wk) 10 wks (60 min x 7 d/wk)</td>
<td>Met for social interaction for same frequency as intervention group (n=18) mean 65</td>
<td>Max concentric strength: Knee flexors (Y) ¶ Knee extensors (N) ¶ Ankle dorsiflexors (N) ¶ Ankle plantarflexors (N) ¶ Muscle latency: Rectur femoris (Y) ¶ Semitendinous (N) ¶ Gastrocnemius (N) ¶ Anterior tibialis (N) ¶</td>
</tr>
<tr>
<td>Lin et al. (2009)</td>
<td>USA</td>
<td>American Journal of Recreation Therapy</td>
<td>n=15</td>
<td>Healthy community-dwelling attendees at a senior day care unit</td>
<td>Therapeutic dance movement: &quot;Dancing Heart Program&quot;</td>
<td>12 wks (60 min plus 30 min story telling x 1 d/wk)</td>
<td>Usual physical activities (n=7)</td>
<td>-Sit and reach (N) ¶ -Coordination test (N) ¶ -Upper body endurance (N) ¶ -34 foot walk (N) ¶</td>
</tr>
<tr>
<td>McKinley et al. (2009)</td>
<td>Canada</td>
<td>Journal of Aging &amp; Physical Activity Canada</td>
<td>n=25</td>
<td>Healthy community-dwelling, older adults at risk for falls</td>
<td>Community-based Argentine tango dance</td>
<td>10 wks (120 min x 2 d/wk)</td>
<td>Walking</td>
<td>30s SCS (Y) 0.7**</td>
</tr>
<tr>
<td>Nnodim et al. (2006)</td>
<td>USA</td>
<td>Journal of American Geriatric Society</td>
<td>n=213</td>
<td>Older adults with mid impairment to perform unilateral stance and tandem walk</td>
<td>Combined balance and stepping training (CBST) versus Tai Chi</td>
<td>10 wks (60 min x 1 d/wk)</td>
<td>Tai Chi (n=106) mean 78</td>
<td>SLS (Y*) ¶ Tandem stance (Y*) ¶ Max step length (Y*) ¶ Rapid step test (Y*) ¶ TUG (Y*) ¶</td>
</tr>
<tr>
<td>Robertson et al. (2002)</td>
<td>New Zealand</td>
<td>American Geriatrics Society</td>
<td>n=1016</td>
<td>Community-dwelling population</td>
<td>Home strengthening and balance retraining designed to prevent falls</td>
<td>7-9 months (30 min 3 x d/wk + x 2 d/wk walking). No of falls recorded for 1-2 years</td>
<td>Usual physical activities</td>
<td>Number of falls (Y*) 0.5** Number of injuries from falls 0.4** 4-test balance scale(Y*) 0.3** 30s SCS (Y*)</td>
</tr>
<tr>
<td>Study</td>
<td>Country, Journal</td>
<td>Group(s)</td>
<td>Intervention/Exercise Details</td>
<td>Effect Size Calculation</td>
<td>Effect Size</td>
<td>Comments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------</td>
<td>-------------</td>
<td>--------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shigematsu et al. (2002)</td>
<td>Japan, Age and Ageing</td>
<td>Healthy, community-dwelling</td>
<td>Dance-based aerobic exercise 12 wks (60 min x 3 d/wk)</td>
<td></td>
<td></td>
<td>Half squat (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SLS eyes open (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>eyes closed (Y*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 min walk test (Y*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hand grip strength (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hand reaction time (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Foot tapping (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>0.1**</td>
<td>Mean ± SD not reported and unable to be estimated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.08**</td>
<td>** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0**</td>
<td>* Intervention group effect size larger than control group effect size</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.6**</td>
<td>** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.2**</td>
<td>* Intervention group effect size larger than control group effect size</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.24**</td>
<td>** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.42**</td>
<td>** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sofianidis et al. (2009)</td>
<td>Greece, Journal of Aging and Physical Activity</td>
<td>Healthy community-dwelling elderly</td>
<td>Traditional Greek dance classes 10 wk (60 min x 2 d/wk)</td>
<td></td>
<td></td>
<td>Sharpened Romberg (Y*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SLS (Y*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dynamic weight shifting(Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>0.23**</td>
<td>Mean ± SD not reported and unable to be estimated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>0.46**</td>
<td>** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>2.0**</td>
<td>** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wong et al. (2009)</td>
<td>Taiwan, American Aging Association</td>
<td>Healthy experienced Tai Chi practitioners</td>
<td>Tai Chi 4 years (30 min x 5 d/wk)</td>
<td></td>
<td></td>
<td>Single foot reaction (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Double foot reaction (Y*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>¥</td>
<td></td>
<td>Mean ± SD not reported and unable to be estimated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>¥</td>
<td></td>
<td>** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young et al. (2007)</td>
<td>Australia, Physiotherapy and Exercise Science</td>
<td>Healthy sedentary postmenopausal Caucasian women</td>
<td>Line dancing: 12 months, (60min x1d/wk) Squats (x5 d/wk) Foot stomping (4 left right stomps x 2d/wk)</td>
<td></td>
<td></td>
<td>TUG (Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SLS (Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Femur bone density(Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Spine bone density (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Loaded squats (Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Step velocity Forward (N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Step velocity Lateral (Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>1.0 Gr1: 1.0 Gr2: 1.0 Gr3: 2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>2.0 Gr1: 2.0 Gr2: 1.1 Gr3: 1.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>0.4 Gr1: 0.4 Gr2: 0.4 Gr3: 0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>0.1 Gr1: 0.2 Gr2: 0.2 Gr3: 0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>1.0 Gr1: 1.6 Gr2: 1.2 Gr3: 1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>0.1 Gr1: 0.5 Gr2: 0.5 Gr3: 0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>1.4 Gr1: 0.7 Gr2: 0.7 Gr3: 0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Intervention group effect size larger than control group effect size
** Effect size calculation where possible: Cohen’s d = (post-mean – pre-mean) / (pre-standard deviation)
¥ Mean ± SD not reported and unable to be estimated
Key: SOT Sensory Organisation Test, SCS: Seated Chair Stand, 30’s SCS: 30 Second Seated Chair Stand, BBS: Berg Balance Scale, SLS: Single Leg Stance, TUG: Timed Up and Go, FSST: Four Square Step Test
5.1.2 Dance studies that measured muscular endurance of the lower extremity

From the 10 studies that measured muscular endurance of the lower extremity all authors adopted a variety of squatting outcomes. The majority of studies (8 out of 10) used the common SCS outcome with one author using a full squat (Young et al., 2007), and another using a half squat outcome (Shigematsu et al., 2002). All individual studies that used the SCS outcome, except for the Keogh et al., (2012) study, observed statistically significant (p<0.05) improvements and positive effect shifts post-intervention compared to controls (Eyigor et al., 2008; Holmerova et al., 2010; Hopkins, 1990; Hui et al., 2009; Lin et al., 2008; McKinley et al., 2008) or pre-to post-intervention (Robertson et al., 2002). Moreover, even when including the Keogh et al., (2012) study, statistically significance improvements in muscular endurance was observed across the studies with a range of effect sizes (p<0.05, effect size range d=0.2 - 2.0).

One study used an isometric half squat outcome on females aged between 72 to 78 years after 12-weeks of participation in a dance-based aerobic class three times per week, compared to a non-dancing controls (Shigematsu et al., 2002). The authors did not state how they came to select this outcome or the reliability or validity. A non-significant statistical result and trivial effect size was observed post-intervention for the half-squat (p>0.05, d=0.1). Therefore dance was found to be ineffective at improving lower extremity muscular endurance as measured with a half squat outcome in this study.

The second study measured loaded squatting ability after a 12-month line dancing intervention (Young et al., 2007). There were three groups in total. All three groups completed the line dancing class once a week, two of the groups additionally performed progressively loaded squats five times a week, and one of those groups performed an additional four left right foot stamps per day. All three groups reached statistical significance and large to very large positive effect sizes (d=1.0, d=1.6, d=1.2) respectively, at post-intervention follow up (Young et al., 2007).

5.1.2.1 Summary of dance studies measuring muscular endurance of the lower extremity

In summary, it appears that participants taking part in dance exhibited moderate to large, effect sizes pre-to post-intervention for lower extremity muscular endurance. The intervention dose which brought about meaningful results ranged between one to three sessions per week, lasting 12-weeks to 12-months. Given the association between lower extremity muscular endurance and
the risk of falling (Rubenstein et al., 2001), it follows that dance could be an effective intervention to reduce the number of falls by increasing muscular endurance of the lower extremity.

5.1.3 Dance studies that measured balance

Balance tests encompass those assessing static balance, dynamic balance or both static and dynamic balance combined. Measurable outcomes for dynamic balance usually involve stepping and therefore could be considered either as a dynamic balance outcome and/or a gait outcome. This section will consider dance studies that implemented outcome measures that predominantly challenges balance more than gait. From the 16 dance studies 12 measured static and/or dynamic balance.

5.1.3.1 Single leg stance (SLS)

Even though 85% of falls occur during dynamic situations, only two studies measured dynamic balance, nine studies measured static balance and one measured both with the BBS. Five studies implemented the SLS outcome to measure static balance (Hong, Li, & Robinson, 2000; Hopkins, 1990; Nnodim et al., 2006; Shigematsu et al., 2002; Young et al., 2007), with four of those studies reporting positive effect shifts (range d=0.4-2.0, average d=0.9) when compared to controls, that attained statistical significance (p<0.05) pre-to post-intervention (Hong et al., 2000; Hopkins, 1990; Shigematsu et al., 2002; Young et al., 2007). The fifth study investigated whether a combined balance and stepping class (combined intervention) was as effective in reducing risk factors for falling as Tai Chi classes (Nnodim et al., 2006). The authors found that the combined intervention was 3.5 times (odds ratio estimate) more likely to improve bipedal static balance and twice as likely to improve single leg balance, compared to the Tai Chi (Nnodim et al., 2006). However, higher dropout rates in the combined intervention (29) compared to the Tai Chi intervention (18) was apparent. This may be pertinent since the intervention required participants to repetitively jump over obstacles and step up curbs which may have "exacerbated musculoskeletal conditions" as the authors stated (Nnodim et al., 2006). Therefore, the combined intervention may be more effective at reducing risk factors for falling than Tai Chi, but may not be an exercise older adults would adopt into a regular exercise program. Overall, several studies note improvements in SLS times after dance interventions, which may be because dance often requires individuals to weight bear in unilateral postures (Keogh et al., 2009).
5.1.3.2 Berg balance scale (BBS)

It has been suggested that outcomes that measure both static and dynamic balance may be unattractive to researchers as they are time costly for both researchers and participants (Cowley & Kerr, 2003). This may be why there was only one study that measured both static and dynamic balance that required participants’ to take part in a Turkish folk dance class once a week, over an 8-week period (Eyigor et al., 2008). The authors reported a statistically significant improvement in the BBS score at the 5% level in the intervention group (d=0.5), compared to the non-exercise control group, which did not change appreciably (d=0.1), although this was deemed unlikely to represent a meaningful clinical change as a ceiling effect may have been operant as both groups were in the 95th percentile for baseline measures. In addition to the dance class, the intervention group were asked to complete rehabilitation exercises and walk for 30 min at least twice a week and therefore the results from this study cannot be attributed solely to dance (Eyigor et al., 2008).

5.1.3.3 Sway

Two studies report changes in balance as measured by sway. The first study recruited 13 community-dwelling older adults (mean age 68 ± 4.4 years) who attended a modified jazz class once a week for 15-weeks with no control group (Alpert et al., 2009). Bipedal static sway was measured once with eyes open, eyes closed, and with visual feedback (about which the authors did not give further details on). The three scores were combined and presented as one sway figure. The second study recruited a group of 14 participants (mean age 70.89 ± 5.67) who performed traditional Greek dance class, twice a week for 10-weeks and were compared to a non-dance controls (Sofianidis et al., 2009). The outcome for this study was bipedal sway as well as SLS sway, and dynamic weight shifting measures, (which required participants to lean without stepping and then return to their upright position). Both studies presented group mean change of variables.

The modified jazz intervention was associated with a ‘large’ effect size and statistically significant change in bipedal stance post-intervention (d=1.1, p=0.01). In contrast the Greek dance intervention observed a ‘trivial’ effect that did not attain statistical significance (d=0.18, p=0.18) for bipedal sway, but did note statistically significant reductions in both COP displacements; mediolateral (d=0.6, p=.001) and anteroposterior (d=0.46, p=.003) in SLS sway and dynamic weight shifting sway (d=2.0, p=0.01) (Sofianidis et al., 2009).

From the two sway studies reviewed it is unclear whether bipedal static sway improves after dance interventions lasting 10 to 15-weeks. Reductions in sway parameters were observed more so in challenging postures such as the SLS and dynamic sway postures, which may occur because dance is mostly a dynamic activity rather than static. However, these findings should be interpreted with
caution because of the low number of participants in each study. Furthermore, it is uncertain how we interpret results from sway as it is still unknown how much sway is desirable (Mientjes & Frank, 1999).

5.1.3.4 Summary of dance studies measuring balance

Dancing one to three times weekly is likely to increase balance performance in older adults. Participation in dance appears to improve static balance as measured by the majority of studies. However, evidence surrounding improvements in dynamic balance and sway after dance interventions is less convincing. Only two dance studies measured sway and two measured dynamic balance. All three studies had small sample sizes. Therefore, it is not possible to draw definitive conclusions about the effects of dance on dynamic balance and sway. Although used as an index of balance, the degree of postural sway has not been associated with risk of falling and therefore sway outcomes may still remain non-specific to fall prevention research.

5.1.4 Dance studies that measured gait

From the dance studies reviewed, 10 studies measured gait or stepping ability which will also be a measure of dynamic balance to some degree (Podsiadlo & Richardson, 1991). The most commonly used outcome measure was the TUG followed by two studies that measured gait velocity or stepping reaction times.

5.1.4.1 Timed up and go (TUG)

From the eight studies that used the TUG or a modified TUG test, the pooled mean effect size was moderate \( (d=0.6) \) with a wide range \( (d=0.1-2.0) \). Six studies were observed to have a statistically significant \( (p<0.05) \) reduction in the time it takes to complete the TUG test compared to controls (Federici, Belligamba, & Rocchi, 2005; Holmerova et al., 2010; Hopkins, 1990; Hui et al., 2009; Nnodim et al., 2006; Young et al., 2007). Two studies recorded trivial effect sizes for the TUG compared to the controls (Keogh et al., 2012; Lin et al., 2008). One study proposed the trivial effect size \( (d=0.1) \) may have been attributed to the small sample size \( (n=8) \) and short duration of intervention of 10 weeks (Lin et al., 2008). However, effect size are not directly dependent on sample size and exercise adaptation's can occur within three weeks after a training stimulus (Macaluso & De Vito, 2004). The other study explained that their trivial effect size \( (d=0.1) \) may have been present for the same reason stated previously for the SCS outcome, from a high participant baseline measure of the intervention group, compared to the control group, and also compared to
participant baseline measures from two studies (Holmerova et al., 2010; Young et al., 2007). However, the Keogh et al. (2012) study showed statistically significant improvements in the dynamic gait outcome (FSST) and details of these results will be considered in a later section.

5.1.4.2 Four square step test (FSST)

The FSST, which measures both multidirectional dynamic balance and stepping speed, was used in the Keogh et al. (2012) study. Participants who performed the FSST and who danced once and twice weekly improved significantly (p=<0.05) compared to controls, without any change to the other risk factors for falling (muscular endurance or balance). Improvements in the group dancing twice weekly (d= 0.30, p= 0.03) were less than in the group dancing once weekly (d=0.62, p=0.04) (Keogh et al., 2012). The authors suggested improvements were minimal in the group dancing twice weekly because of a higher baseline reading, allowing less room for improvement (Keogh et al., 2012). Therefore, the findings from the Keogh et al., (2012) study show that risk factors for falling can improve independently of one another, as multidirectional dynamic balance improved, while muscular endurance and gait ability did not.

5.1.4.3 Stepping motor response

Two other studies tested similar movements to the FSST, but with a primary purpose of measuring stepping motor response (Wong et al., 2009; Young et al., 2007). Both outcomes assessed motor response time and therefore how quick an individual may respond to gain their balance after a trip or slip, thus possibly preventing a fall and potential injury (Wong et al., 2009). One author measured stepping velocity after a 12-month line dancing intervention. The measurable outcome required participants to lean in a sagittal and frontal plane, as they were going to fall, and catch themselves by placing their foot on the ground (Young et al., 2007). The distance their foot travelled was measured as well as the time it took to lift their foot off the ground and place it back down. The data were presented as step velocity speed (m/s). Trivial effect sizes were recorded for forward step velocity (d=0.1) in contrast to the lateral stepping, which showed large to very large effect sizes (d=1.4) compared to controls. The lateral motor response time findings are concordant with the second study that also measured motor response using a slightly different method (Wong et al., 2009).

Wong et al., (2009) measured motor response of 31 experienced Tai Chi instructors (with a minimum experience of four years teaching) compared to 30 sedentary community-dwelling older adults. A response time paradigm was implemented, in which participants were timed in response to a signal, to move in an anterior or lateral direction, with one or two feet. The Tai Chi instructors
had statistically significant improvements in both single (p=0.001) and dual foot response times (p=0.01) in both directions compared to the sedentary control groups. The effect sizes were larger in the lateral direction (d=0.9) compared to the anterior direction (d=0.4) (Wong et al., 2009). The findings by Wong et al., (2009) and Young et al., (2007) suggest that dance may reduce falls and fall-related injuries by increasing stepping motor response time, predominately in the lateral direction.

5.1.4.4 Summary of dance studies measuring gait

Dance studies that measure gait ability will, to some extent, measure dynamic balance concurrently. The typical dose of intervention was approximately 12-weeks long, attended one to three times weekly. Dynamic gait improved in the majority of studies and therefore it may be inferred that dance may improve dynamic balance. Additionally, dance interventions may be successful at improving stepping motor response time in older adults (Wong et al., 2009; Young et al., 2007) and therefore may help prevent injuries from falls. Further, investigative dance research recording the direct number of slips and trips that resulted in a prevented fall, compared to a control group, should be carried out to validate the claims by Young et al., (2007) and Wong et al., (2009).
6.0 Summary of literature review

The number of falls and fall-related injuries is likely to rise as the proportion of older, less healthy adults' increases throughout the developed world. The New Zealand Ministry of Health has previously subsidised the Otago Exercise Program and Modified Tai Chi classes, to enable greater public access in an effort to decrease the growing socioeconomic impact of falls (Robertson & Campbell, 2008). However, in an economic climate of fiscal constraint, government funding was terminated for both the Otago Exercise Program and the Modified Tai Chi classes, impacting on the number of older adults accessing fall preventative interventions. Therefore, research investigating different fall preventative interventions that are effective, physically suitable and appealing to the older adult population, such as dance, may be worth investigating.

It is well accepted in the falls prevention literature that muscular weakness of the lower extremity, balance deficits and gait deficits are the most influential physical risk factors for falling (Rubenstein et al., 2001). The existing literature surrounding dance, as a fall prevention intervention, appears to support the conclusion that dance can reduce risk factors for falling and therefore may reduce falls. Nonetheless, indirect outcomes (such as reduction of risk factors) are of lesser validity than direct measures (e.g. number of falls) and this limitation should be considered when interpreting the existing literature. Six of the dance intervention studies identified statistically significant improvements (p<0.05) in all three risk factors for falling following interventions lasting from 8-weeks to 12-months and results were similar whether dancing one or three times weekly (Eyigor et al., 2008; Holmerova et al., 2010; Hopkins, 1990; Nnodim et al., 2006; Robertson & Campbell, 2008; Young et al., 2007).

Dance offers an attractive fall preventative intervention for older adults because dance can take many forms involving a wide range of body movements and physical demands, can be modified to suit different participant capabilities, can be performed in a variety of settings, does not require highly trained specialists or many resources, and may appeal to a wide range of individuals (Keogh et al., 2009). In addition to fall-related outcomes, dance exercise has other health benefits that can improve physical function (Holmerova et al., 2010), such as increased bone density (Young et al., 2007), improved neurodegenerative disorders (Marchant, Sylvester, & Earhart, 2010; Pickering et al., 2007) and reduce cardiovascular health risks, all of which would further lower medical expenditure.

Dance participation encourages fun and enjoyment and promotes social interaction and a sense of community which is beneficial to older adults who are predisposed to social isolation (Campbell & Robertson, 2010; Keogh et al., 2012). Because of these factors, dancing would appear to be a beneficial physical activity for older adults who are at high risk of falling, and live independently in
a community-dwelling or retirement village-dwelling environment. Therefore, older adults may be more likely to adopt dance into a regular exercise program, compared to other exercise modes.

While the majority of research supports claims that dance may be an effective fall preventative intervention, there are areas within the literature that are not well researched and further investigations should consider the following issues where possible:

a) fall preventative researchers should implement the ProFaNE methodology to encourage comparative research between dance studies and consistency of outcome measures and reporting of mean and standard deviations to allow direct comparisons and calculable effect size;

b) all the studies reviewed except for one recorded indirect measures of falls and therefore fall prevention claims are only estimations and future studies should consider recording direct fall rates where possible;

c) the dose of intervention and style of dance for optimal fall prevention for different functioning older adults still remains unclear;

d) it is known that the prevalence of chronic conditions in older adults is high (Wang et al., 2006). Future dance studies should consider including symptomatic older adults with age-related conditions because all studies, except the study by Robertson et al, (2003) excluded participants with chronic conditions and therefore the current literature may not be generalisable to older adults with chronic conditions;

e) small sample sizes, and solely or predominately female samples were present in all studies, and future studies would have greater generalisability if larger sample sizes and more balanced male to female ratios were employed.
7.0 Background to research project between Unitec New Zealand and Dance Aotearoa New Zealand

Dance Aotearoa New Zealand (DANZ) is a national organisation for New Zealand Dance that promotes dance education and development. In March 2010, DANZ developed a mobility dance class aimed at promoting physical activity, mobility and enjoyment in adults over the age of 65. DANZ designed the mobility dance program with particular sensitivity to the needs of older adults (Molloy & Jordan, 2012). The DANZ organizers approached Unitec’s Department of Osteopathy with an invitation to work alongside their dance program to conduct an independent research project to investigate potential health-related benefits associated with participation in their dance project.

In response to DANZ’s invitation, two thesis research projects were run concurrently, in collaboration with DANZ and Unitec New Zealand. The current research project investigated whether dance is effective at reducing risk factors for falling in independent community-dwelling older adults residing in New Zealand. The second thesis research project (Russell, 2013), investigated self-perceived balance confidence and quality of life and is currently in submission.
8.0 References


Russell, T. (2013). *The Effects of Dance on Fall-Related Self-Efficacy and Quality of Life and the Relationship between Psychosocial and Physical Effects in Older Adults in New Zealand (in submission).* Masters of Osteopathy, Unitec, Auckland.


Note to reader: This manuscript has been prepared according to the instructions for Authors for the *Archives of Gerontology and Geriatrics*. The word count has been exceeded in order to allow inclusion of details and discussion in order to meet the learning requirements of the thesis. The use of square brackets in the manuscript make reference to other parts of the thesis e.g. [Appendix A].
Title

The effects of dance on physical risk factors that influence falling in older adults

Stephen Chesterfield
Department of Osteopathy
Unitec Institute of Technology
Private Bag 92025, Auckland 1142

Email: chesterfieldsteve@hotmail.com
Tel: +64 9 815 4321 x8197
Abstract

**Background:** Falls are a substantial source of morbidity and mortality in older adults. Dance may offer fall prevention benefits for older adults who are at high risk of falling.

**Methods:** A double-cohort pilot study was conducted to investigate the effects of group-based dance on physical risk factors, in independent community-dwelling and retirement village-dwelling adults over 65-years of age. The first cohort of participants (n=7) were independent community-dwelling older adults who took part in a dance-based mobility class; the second cohort of participants (n=14) were independent residents of a retirement village who undertook folk dancing classes. Classes were scheduled once weekly, for 9-consecutive weeks, followed by social time. Outcome measures included a 30 s seated chair stand, single leg stance, a four square step test and bipedal static sway.

**Results:** Improvements were observed pre-to post-intervention, for seated chair stand and four square step test in both cohorts and no meaningful improvement was observed for sway variables in both cohorts. Cohort 1 mobility dance: seated chair stand (d=0.50, p=0.04), single leg stance (d=0.57, p=0.03), four square step test (d=0.72, p=0.01). Cohort 2 folk dancing: seated chair stand (d=0.13, p=0.01), single leg stance (d=0.35, p=0.14), four square step test (d=0.55, p=0.03).

**Conclusion:** In both cohorts, participation in dance classes was associated with favourable reductions in risk factors for falling. These preliminary findings should be further investigated in a larger scale, randomised controlled trial.

**Key words:** fall prevention, exercise, dance, balance, elderly.
1.0 Introduction

In New Zealand the older adult population, defined as those aged 65 years or older (Robertson & Campbell, 2008), is forecast to double to one million between 2009 and 2020 (Statistics New Zealand, 2009). Falls are the leading cause of injury that require hospitalisation in older adults (ACC, 2005; Sturnieks et al., 2008) and are associated with high rates of morbidity and mortality (Alpert et al., 2009; Ersoy, MacWalter, Durmus, Altay, & Baysal, 2009; Sofianidis et al., 2009). Falls may be caused by instability and then miss-stepping or tripping on objects. Older adults lose consciousness more often due to impaired brain circulation, simple fainting, circulatory problems, metabolic problems, or primary neural problems all of which can predispose older adults to sustain more fall related injuries. Although older adults fall less often than children and athletes they are more vulnerable to the injury effects of falls (Rubenstein & Josephson, 2002). A third of older adult New Zealanders fall each year with 20 to 30% of those who fall sustaining moderate to severe injuries (ACC, 2005; Robertson & Campbell, 2008). Older adults are more vulnerable to fall-related injuries requiring hospitalisation (Robertson & Campbell, 2008; Sturnieks et al., 2008). A increased incidence of falling, combined with a vulnerability to injury within the older adult population contributes to a high financial and social burden (ACC, 2005; Campbell & Robertson, 2010; Pollock & Graves, 1994; Robertson & Campbell, 2008). The cost to New Zealand’s Accident Compensation Corporation for fall-related claims for older adults amounted to $82 million in the 2006/07 fiscal period, and approximately 50% of this total was attributed to adults over the age of 80 years. These statistics under-represent indirect costs such as social burden, including to lowly-paid caregivers and family, which are not included in the financial analysis (Robertson & Campbell, 2008).

The growing number of older adults and substantial socioeconomic impact of falls, had lead New Zealand governmental agencies to provide subsidised fall preventative interventions in an effort to reduce fall-related health expenditure (Campbell & Robertson, 2010). Two physical exercise interventions, the Otago Exercise Program and a Modified Tai Chi class, as well as one non-exercise intervention (Vitamin D supplementation), were included in the subsidised initiatives (Campbell & Robertson, 2010). Physical activity is classed as an activity that enhances physical fitness or overall health and wellbeing. In 2011, funding for the Otago Exercise Program and Modified Tai Chi classes was terminated.
The termination of subsidised exercise interventions may reduce the number of New Zealand older adults accessing fall preventative interventions. Therefore, research investigating other fall preventive interventions may be worthwhile to help offer alternative fall preventative strategies for the older adult New Zealand population.

In addition to external risk factors for falling (e.g. medication side-effects) and environmental risk factors for falling (e.g. loose carpet), internal physical risk factors (Rubenstein et al., 2001) have been identified in several reviews and include, in order from most influential to least, muscular weakness of the lower extremity, balance deficits, gait deficits, visual deficits, arthritis, depression and cognitive impairment (Caby et al., 2011; Ersoy et al., 2009; Lamb et al., 2005; Pluijm et al., 2006; Rubenstein et al., 2001). It is well documented that some of these physical risk factors can be modified with exercise interventions (Gillespie et al., 2010; Keogh et al., 2009; Lord, Ward, Williams, & Zivanovic, 1996; Province et al., 1995; Taaffe, Duret, Wheeler, & Marcus, 1999; Young et al., 2007). Fall preventative exercise interventions are advantageous, compared to non-exercise interventions, such as vitamin D supplementation, hip protectors or cataract surgery, as exercise interventions are inexpensive, have many secondary health restorative and related benefits (Robertson & Campbell, 2008) and, if performed in a group, encourage regular exercise habits and opportunities for social interaction (Deforche & De Bourdeaudhuij, 2000).

The Prevention of Falls Network Europe (ProFaNE) are a collaborative group who promote best practice in fall prevention and have established an exercise modality classification (Lamb et al., 2005). Not all exercise modalities may be suitable or appealing to different demographics within the older adult population. Several reviews have compared the fall preventative benefits of each modality. One exercise modality called ‘3D exercise’, which is referred to ‘3D’ as it requires participants to move their bodies in three dimensions (flexion/extension, abduction/adduction and rotation of limbs, trunk and neck) and includes activities such as dance, Tai Chi and qi gong. 3D exercise has consistently shown to be more effective at reducing risk factors for falling than any other single exercise modality (Costello & Dedelstein, 2008; Gillespie et al., 2010; Howe et al., 2008).

Robertson and Campbell (2008) recommend that a variety of exercise interventions should be available to appeal to a wide range of older adults. This is to accommodate
individual exercise preference and a range of physical limitations within the older adult population (Robertson & Campbell, 2008). Dance, compared to Tai Chi and the Otago Exercise Program, could be an additional fall preventative intervention that may appeal to different older adult demographics (Keogh et al., 2009). In addition, dance can be an enjoyable activity, which can enhance motivation and long term exercise compliance (Holmerova et al., 2010). Furthermore, dance may be an attractive activity for older adults as it promotes social interaction and a sense of community (Holmerova et al., 2010; Keogh et al., 2009). Therefore, older adults may be more likely to adopt dance as a regular recreational activity than other forms of exercise (Keogh et al., 2009).

The majority of literature investigating dance as a fall preventative intervention indicates that dance can reduce direct fall rates (Robertson et al., 2002) or risk factors for falling (Eyigor et al., 2008; Federici et al., 2005; Holmerova et al., 2010; Hopkins, 1990; Hui et al., 2009; Keogh et al., 2009; Lin et al., 2008; McKinley et al., 2008; Nnodim et al., 2006; Shigematsu et al., 2002; Wong et al., 2009; Young et al., 2007). Most previous studies have excluded participants with chronic conditions. In New Zealand the older adult population have higher mortality rates and hospitalisations from most chronic conditions, infections and unintentional injuries, compared to their younger counterparts aged between 50-64 (Wang et al., 2006). Therefore, as chronic conditions are more prevalent in older adults, dance study samples should include individuals with chronic conditions in order to better represent an older adult New Zealand population. Only one interventional dance study involving older adults has been conducted in New Zealand. This study by Keogh et al., excluded certain chronic conditions and the findings from this study conflict with the wider dance literature and need substantiating. Therefore, the aim of this study was to investigate the effect dance has on risk factors for falling in a representative sample of New Zealand older adults independently residing in a community-dwelling and retirement village-dwelling setting.
2.0 Methods

2.1.1 Study setting and participants

This was a double-cohort pilot study. All participants were over 65 years and living independently. Cohort 1 were community-dwelling enrollees in “Dance Mobility” classes organised by Dance Aotearoa New Zealand (DANZ) in Mt Albert, Auckland. The Dance Mobility classes were advertised through flyers, local papers, community notice-boards and the DANZ website. Due to timing of the program, all participants had attended the dance program for 9 or 18 weeks previously. A small sample size and previous dance experience of participants lead the investigators to organise a second dance intervention. Due to logistical constraints collaboration with DANZ was not possible and therefore the investigator organized a second dance class in collaboration with Selwyn retirement village. Cohort 2 were residents of Selwyn retirement village (Point Chevalier, Auckland) who responded to advertisements distributed within the retirement village inviting them to attend ‘Folk Dancing’ classes. They had not taken part in dance in the past six months. Those attending the initial session were informed about the aims of the study and invited to consider participating. A non-restrictive exclusion criterion allowed participants with a variety of different chronic conditions to be involved in the study. One participant in the DANZ cohort took part in the dance class but opted not to be part of the research. All participants in the Selwyn cohort volunteered to be part of the dance and study, although, one person was excluded from the dance and study with exertional angina from the Selwyn cohort for safety reasons. Participants who volunteered to take part in the study filled out a pre-exercise medical history questionnaire [Appendix G] to screen for any potential contraindications to performing light to moderate cardiovascular exercise. The study was approved by the Unitec Research Ethics Committee (UREC Approval 2011-1199, 2011-1248) [Appendix C]

2.1.2 Study design

Both dance programs consisted of a weekly one-hour dance class. Each class included a 5 – 10 min warm up, 35 – 40 min of dance exercise, followed by a five-min cool down and ended with 30 min of social interaction. Each program was conducted over nine consecutive weeks.
2.1.2.1 Cohort 1: DANZ Dance mobility

The Dance Mobility program was organized by DANZ and Creative Communities and performed at a local community hall delivered by two professional dance instructors with over 50 years of combined teaching experience. The program was specifically designed to meet the needs of older persons, and was aimed at “increasing balance, coordination and strength, based on contemporary dance and ballet exercises” (Molloy & Jordan, 2012). The dancing style emphasized mindful movements, balance, postural awareness, as well as creative tasks and participant interaction. After the warm up, chair exercises, such as large peripheral limb movements, sitting to standing or navigating around the chair, were completed for 20 min, followed by 20 min of progressive choreographed dance routines. Music from the 1930s and 1940s was chosen in an attempt to enhance relevance and reduce anxiety (Molloy & Jordan, 2012).

2.1.2.2 Cohort 2: Selwyn Folk dancing

The folk dance program was organised by Unitec New Zealand in conjunction with Selwyn retirement village and delivered by folk dance instructor with 10 years experience. The program took place at the Point Chevalier Selwyn Village hall between January and March 2012. The dancing style emphasized balance, strength, co-ordination and interaction with one another. Exercises were performed standing and those needing a rest between songs were encouraged to do so although the class was adapted to meet participant ability and interests. After warm-up the participants followed a maximum of five progressive dance routines either performed in a circle or in a line. The dance routines would require partner involvement and dancing with everyone in the class lasting for 30 – 35 min. The music and dance movements were drawn from traditional folk dance, including Yugoslav, Shegra, St George Cross, Chinese, Greek, Israeli, German and Tennessee Walk.

2.1.3 Outcome measures and procedures

Data collection commenced in March 2010 for the DANZ cohort and January 2011 for the Selwyn cohort. All outcome measures were assessed at baseline during the first dance and at follow-up in the ninth and final week. The physical assessment consisted of lower limb muscular endurance, static balance, multidirectional dynamic gait and balance and sway.
These were measured with the 30 s seated chair stand (30 s SCS) (Rikli & Jones, 1999),
single leg stance (SLS) (Muir et al., 2010), four square step test (FSST) (Whitney et al.,
2007) and sway was measured with a portable sway-plate. Demographic data, exercise
habits and medical conditions were recorded at enrolment. Participant attendance and
dancing time was monitored at each session. Psychosocial measures were collected
simultaneously for another study using the same cohort of participants.

Participants were required to complete a 5 – 15 min warm up prior to both data collection
points. A demonstration of all measurable outcomes were shown by the researcher or
research assistants to help the participants clearly understand what was required with no
ambiguity. To mitigate risk of injury and maintain consistent measures participants were
instructed before each test to “do the best you can but never push yourself to a point of
over-exertion or beyond what you think is safe” (Rikli & Jones, 1999).

2.1.3.1 30 s seated chair stand (30 s SCS)

Lower extremity muscular endurance was recorded with a 30 s SCS, which included a
practise repetition and has been shown to have very high test-retest reliability (ICC >
0.90) (Miotto et al., 1999; Rikli & Jones, 1999). The protocol began by having the
participants sitting on a secured chair (seat set 43cm above ground level) with no arm
rests. The participant’s heel of the dominant foot was placed on the toe of the other foot,
spaced shoulder width apart, with arms crossed at the wrist and held against their chest
(Jones et al., 1999). On an audible signal the participant stood and the maximum number
of repetitions performed in 30 s was recorded. A rest time (45 s – 60 s) between 3 sets was
allowed for muscle recovery.

2.1.3.2 Single leg stance (SLS)

Static balance was measured with the SLS, previously used as a standalone balance
measure with good reliability (ICC ~ 0.74) (Cowley & Kerr, 2003; Muir et al., 2010).
Participants were instructed to “stay balanced as long as you can without moving your
arms, taking a step or touching the ground with your other foot.” Arms were crossed at the
wrist and held against their chest, while they raised their non-preferred foot off the
ground and the timer was started with a maximal cut of point of 30 s (Miotto et al., 1999).
The protocol was repeated three times with a 20 s – 30 s break between. The timer was stopped if any of the following occurred: a) arms moved off the participants chest, b) the planted foot moves from the starting position, or c) the opposite foot in the air touches the ground (Kyaguchi & Furutani, 1998).

2.1.3.3 Four square step test

Multidirectional dynamic balance and gait was recorded using the FSST which has excellent test re-test reliability (ICC > 0.90) as shown in two previous studies (Dite & Temple, 2002; Whitney et al., 2007).

The protocol required participants to step in a sagittal (side to side) and frontal (forwards and backwards) plane. Two thin pieces of foam, 1 m in length and 5 cm in width, were taped to the ground in a ‘plus sign’ (+) forming four equal quadrants. Each participant started facing forwards with both feet flat on the ground in one quadrant. Participants moved in a clockwise direction around the plus sign to the starting quadrant, then reversed in an anticlockwise direction finishing at the start position. Any part of both feet had to touch in each quadrant. The participants were instructed to “try to complete the sequence as fast and safely as possible without touching the pieces of foam while facing forward during the entire sequence” (Miotto et al., 1999). They performed one practice trial, followed by three recorded timed trials and the mean used in subsequent analysis.

2.1.3.4 Static sway

The Medicapteurs Sway-plate and standard notebook interface computer proprietary S-Plate software version 1.36 were used (Medicapteurs corporation Balma, France). Sampling rate was set at 100 Hz with 300 individual catchment points over a 60 s period measuring the length of path (mm) and area of path covered (mm²).

A recent reliability study (Fisher, 2011) reported 'large to very large' intra-class correlation coefficients (ICC) with a set protocol for adults (d=0.66 – 0.88). A single sheet of paper with two lines drawn on it in a 30 deg angle V-shape was placed over the top of the sway plate to guide stance position. Participants stood barefoot with their heels 4 cm
apart and externally rotated so the medial aspect of each foot were against the lines (each foot pointed 15 deg outward from neutral (Fisher, 2011). Participants were asked to stand as naturally and still as possible, with arms at sides, while looking at a reference point on the wall 4 m in front of them (Fisher, 2011). The participants were told they would be standing for 75 s so they did not anticipate nearing the end of the outcome at 60 s.

2.1.4 Statistical methods

2.1.4.1 Data analysis

Results were analysed using the Statistical Package for Social Sciences (SPSS) software for Windows v19.0.0 (SPSS, IBM Statistics). Categorical demographic data, attendance and change in variables from baseline to follow-up were tested for assumptions of normality using skewness and kurtosis z-scores and the Shapiro-Wilk test, which is recommended for small sample sizes with many tied values (Field, 2009). Data that violated assumptions of normality were presented as non-parametric data with median and interquartile ranges. Data that did not violate assumptions are presented as parametric data with mean and standard deviations. Both data sets were analysed for change using the Wilcoxon rank sum test. Statistical significance was set at p<0.05 and effect sizes were evaluated using the Hopkins scale of magnitudes (W. G. Hopkins, 2002).

3.0 Results

A total of 27 individuals participated in the dance classes of whom 22 volunteered to take part in the study. One participant did not attend for post-measures in the DANZ cohort leaving a total of 7 participants whose data were analysed. The Selwyn cohort had 18 participants enrol for the dance of whom 16 agreed to take part in the study. Unrelated health concerns lead a further 2 participants to withdraw from the dance and study from the Selwyn cohort. Compared to the DANZ cohort, the Selwyn cohort was significantly older and had significantly more participants taking 4 or more medications (p=0.04) (Table 1). There were no significant differences in gender, attendance or dropout rates between cohorts. The DANZ cohort had no male participants and the Selwyn group had a high female to male ratio (Table 1).
For the DANZ cohort, moderate to large effect sizes (range d=0.5 to 0.7) were observed for the 30 s SCS, SLS and FSST, and all attained statistical significance (Table 2a). In the Selwyn cohort a small effect size was observed for the 30 s SCS (d=0.13, p=0.01), a moderate effect size was observed for the SLS outcome (d=0.35, p=0.14), and a large improvement for the FSST was observed (d=0.55; p=0.03). Sway length of path (mm), and area (mm²), in both cohorts, demonstrated high variability and change pre-and post-intervention and was not statistically significant (p>0.14) and effects sizes were trivial to small.

Table 1: Participant descriptive characteristics at enrolment in the study

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Cohort 1 (DANZ) Mobility dance</th>
<th>Cohort 2 (Selwyn) Folk dance</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± SD)</td>
<td>72.4 ± 8.7</td>
<td>81.2 ± 4.4</td>
<td>0.04 [1]</td>
</tr>
<tr>
<td>Attendance (mean ± SD)</td>
<td>84% ± 14</td>
<td>83% ± 8</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>0/7</td>
<td>2/14</td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>7/7</td>
<td>12/14</td>
<td></td>
</tr>
<tr>
<td>History of falls [2]</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Four or more prescription medications [4]</td>
<td>4/7</td>
<td>2/14</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
[1] p-value from independent t-test where Levene’s Test for Equality of Variances p=0.02 values not assumed equal
[2] Fall defined as “an unexpected event in which the participants come to rest on the ground, floor, or lower level” (Lamb et al., 2005)
[3] Individuals presented with 1 or more of the following conditions. Cohort 1 DANZ: Diabetes (n=2), Parkinson’s (n=2), Arthritis (n=1), Glaucoma (n=1), Congestive heart failure (n=1). Cohort 2 Selwyn: Parkinson’s (n=2), Arthritis (n=4), Inner ear disease (n=1)
[4] Falls more prevalent with 4 or more medications (Campbell et al., 1999; Tinetti et al., 1994)
Table 2a: Results presented as parametric data for both cohorts pre-and post-intervention.

<table>
<thead>
<tr>
<th></th>
<th>Pre-intervention (mean ± SD)</th>
<th>Post-intervention (mean ± SD)</th>
<th>Mean Difference</th>
<th>95% CI for Difference</th>
<th>p-value</th>
<th>Effect size [2]</th>
<th>Descriptor [3]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DANZ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30s seated chair stand</td>
<td>10.0 ± 2.4</td>
<td>11.2 ± 3.1</td>
<td>1.2</td>
<td>-1.0</td>
<td>.01</td>
<td>0.04 [1]</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>(freq)</td>
<td></td>
<td></td>
<td>-.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single leg stance (s)</td>
<td>15.1 ± 7.3</td>
<td>19.3 ± 7.9</td>
<td>4.2</td>
<td>-8.0</td>
<td>.2</td>
<td>0.03 [1]</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-square Step Test (s)</td>
<td>11.2 ± 2.9</td>
<td>8.9 ± 2.1</td>
<td>2.1</td>
<td>1.0</td>
<td>4.0</td>
<td>0.01 [1]</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Selwyn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30s seated chair stand</td>
<td>10.5 ± 9.8</td>
<td>11.8 ± 2.7</td>
<td>1.3</td>
<td>-2.2</td>
<td>-0.3</td>
<td>0.01 [1]</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>(freq)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-square step test (s)</td>
<td>11.2 ± 2.7</td>
<td>9.7 ± 2.6</td>
<td>1.5</td>
<td>0.1</td>
<td>3.0</td>
<td>0.03 [1]</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
[1] Significant at the 5% level
[2] Effect sizes were derived by mean difference divided by pre-standard deviation.
[3] Scale of magnitude was evaluated using the Hopkin’s effect size descriptors (W. G. Hopkins, 2002).
Data from both cohorts. Data in Table 2a did not violate assumptions of skewness or kurtosis (>1.96) or the Kolmogorov-Smirnov and Shapiro-Wilk test (>0.05) and therefore is presented as parametric data. Data in table 2b violated assumptions and therefore is presented as non-parametric data with Medians and IQR.
Table 2b: Results presented as non-parametric data for both cohorts pre-and post-intervention.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DANZ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sway length of path (mm)</td>
<td>188.2</td>
<td>180.1</td>
<td>163.3</td>
<td>163.0</td>
<td>-28.0</td>
<td>77.1</td>
<td>0.18</td>
<td>0.13</td>
</tr>
<tr>
<td>Sway area (mm²)</td>
<td>121.0</td>
<td>189.3</td>
<td>83.9</td>
<td>116.0</td>
<td>-40.2</td>
<td>112.0</td>
<td>0.27</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Selwyn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sway length of path (mm)</td>
<td>102.6</td>
<td>48.4</td>
<td>117.2</td>
<td>49.0</td>
<td>-34.4</td>
<td>17.2</td>
<td>0.25</td>
<td>0.18</td>
</tr>
<tr>
<td>Sway area (mm²)</td>
<td>30.0</td>
<td>35.7</td>
<td>28.5</td>
<td>44.7</td>
<td>-15.1</td>
<td>32.3</td>
<td>0.47</td>
<td>0.18</td>
</tr>
<tr>
<td>Single leg stance (s)</td>
<td>10.0</td>
<td>9.8</td>
<td>13.5</td>
<td>12.1</td>
<td>-8.0</td>
<td>1.0</td>
<td>0.14</td>
<td>0.35</td>
</tr>
</tbody>
</table>

[1] Significant at the 5% level
[2] Effect sizes were derived by mean difference divided by pre-standard deviation.
[3] Scale of magnitude was evaluated using the Hopkin’s effect size descriptors (W. G. Hopkins, 2002).
4.0 Discussion

4.1.1 Overview

The objective of this study was to investigate whether participation in two different dance classes, over a 9-week time frame, could change risk factors that have been shown to predispose older adults to falling. The findings of this study showed improvements in most, but not all, of the risk factor variables following intervention. These findings are similar to claims made by other fall preventative dance researchers (Eyigor et al., 2008; Holmerova et al., 2010; Hopkins, 1990; Hui et al., 2009; Nnodim et al., 2006; Robertson et al., 2002; Shigematsu et al., 2002; Wong et al., 2009; Young et al., 2007), and a recent review of dance benefits (Keogh et al., 2009).

The measurable outcomes that challenged participants to use muscular endurance and multidirectional dynamic gait and balance (30 s SCS and FSST) yielded statistically significant improvements in both cohorts. Moderate to large effect sizes were observed with these outcomes except for the trivial effect size observed in the Selwyn cohorts 30 s SCS outcome. Improvements in the 30 s SCS in the DANZ cohort runs parallel to the majority of previous dance studies (Eyigor et al., 2008; Holmerova et al., 2010; Hopkins, 1990; Hui et al., 2009; Lin et al., 2008; McKinley et al., 2008; Robertson et al., 2002). Effect sizes and statistically significant improvements in the FSST outcomes are in line with the previous dance study that used the same outcome measure (Keogh et al., 2012). Only the DANZ cohort improved their SLS significantly and both cohorts yielded non-significant, trivial to small effect sizes for both sway outcomes.

Participants of the current study could volunteer to be part of the study as long as they were deemed safe to exercise and were over 65 years of age. Nearly half of the participants across both cohorts had one or more chronic condition. These exclusion criteria were implemented to be a representative sample of an independent community-dwelling (DANZ) and retirement village-dwelling (Selwyn) older adult New Zealand population. To date there are many dance studies that have excluded participants with conditions (Alpert et al., 2009; Eyigor et al., 2008; Federici et al., 2005; Holmerova et al., 2010; Hong et al., 2000; Hui et al., 2009; Keogh et al., 2012; Shigematsu et al., 2002; Young et al., 2007) compared to studies that have included participants with conditions (Robertson et al., 2002).
4.1.2  Lower extremity muscular endurance

4.1.2.1  Lower extremity muscular endurance: DANZ compared to Selwyn

The current study showed a statistically significant improvement in both cohorts for lower extremity muscular endurance. The DANZ cohort had a moderate effect shift (d=0.5) while the Selwyn cohort did not have any meaningful change (d = 0.1). This difference between cohorts may be explained by the older age of the Selwyn participants which may impede muscular endurance abilities, when compared to the younger DANZ cohort. Several studies support this theory. Muscular endurance reduces over 45 years of age by approximately 0.5% per year and this reduction accelerates past the age of 65 from atrophy, selective hypoplasia, degeneration of fast-twitch fibres and loss of terminal nerve sprouting resulting in a reduction of muscular adaptive abilities (Aoyagi & Shephard, 1992). Furthermore, the DANZ cohort had previous dance experience and therefore a proportion of muscular endurance adaptations may have already taken place prior to baseline measures.

4.1.2.2  Lower extremity muscular endurance compared to similar dance studies

Several researchers have observed similar improvements in lower extremity muscular endurance when compared to the DANZ cohort (Eyigor et al., 2008; Holmerova et al., 2010; Hopkins, 1990; Hui et al., 2009; McKinley et al., 2008; Robertson et al., 2002; Young et al., 2007) with a range of different effect sizes (range d=0.2 to 2.0). This wide range in effect sizes may be part explained by the different weekly frequency of which the participants danced. For example, studies by Eyigor et al., (2010) and Hopkins et al., (1990) required participants to dance three times a week and produced large (d=1.0) to very large (d=1.6) effect sizes, respectively. Clinical guidelines for optimal muscular endurance recommend older adults should perform 15 – 20 repetitions, 2 – 3 times per week (American College of Sports Medicine, 2013). Therefore if these guidelines apply to dance, improvements in muscular endurance would be expected if older adults danced 2 – 3 times per week. Therefore it may be concluded from the DANZ cohort, dancing once weekly may be beneficial for improving muscular endurance of the lower extremity, yet dancing three times per week may be more beneficial.
The current study has shown that 9-weeks of dance can reduce risk factors for falling. A study by Young et al., (2007) demonstrated large effect sizes (d=2.0) following a 12-month dance intervention. It is likely that participation in dance programs over the course of many months would result in greater training stimuli compared to shorter durations. Therefore dance studies that investigate outcomes associated with longer term participation should be undertaken.

4.1.3 Single leg stance (SLS)

The effect sizes noted for the SLS outcome in the DANZ cohort (d=0.5) and Selwyn cohort (d=0.35) are of comparable magnitude to several similar dance studies (Hong et al., 2000; Hopkins, 1990; Nnodim et al., 2006; Shigematsu et al., 2002; Young et al., 2007), although the observed Selwyn group effect was non-significant. It was anticipated that improvements in SLS would be observed in the current study as dance requires both static and dynamic unilateral postures (Keogh et al., 2009). It appears that the mobility dance class may be more effective at improving static balance when compared to the Selwyn intervention. However there are two other reasons why SLS may have improved more in the DANZ cohort compared to the Selwyn cohort. First, balance becomes impaired with age (Jacobson, Thompson, Wallace, Brown, & Rial, 2011) and therefore the larger improvements in the DANZ cohort, compared to the Selwyn cohort may be attributed to the younger age of the participants in the DANZ cohort. The DANZ cohorts previous dance experience may have allowed the DANZ participants to work out at a greater intensity and therefore gain more physical benefits that may help further reduce risk factors for falling.

4.1.4 Multidirectional dynamic gait and balance

Statistically significant, moderate effects in both the DANZ cohort (d=0.7), and Selwyn cohort (d=0.5), were observed for the FSST pre-to post-intervention. A previous study that adopted the FSST observed similar effect sizes to the current study with participants dancing once weekly (d=0.6) compared to twice weekly (d=0.3) (Keogh et al., 2012). Keogh et al., (2012) suggests the larger improvements in the FSST may be because dance incorporates similar movements to that of the FSST and therefore it may be plausible that the specificity training principle may apply (Macaluso & De Vito, 2004), whereby greater
similarities among the dance movements, and the measurable outcome movements, yield significant improvements (Keogh et al., 2012).

4.1.5 Sway

4.1.5.1 Comparisons to previous studies

Both sway outcomes (length of path and area) for both cohorts were not statistically significant at the 5% level pre-to post-intervention and a high variability in standard deviations were observed, more so in the DANZ cohort. (Table 2b). The sway findings of the current study was in line with the Sofianidis et al., (2009) study, but contrasted results observed in the Alpert et al., (2009) study. The study by Alpert et al., (2009) excluded participants with chronic conditions (e.g. Parkinson's disease, diabetes, arthritis) that have been shown to impede balance (Rubenstein et al., 2001), who were on average 4.5 years younger than the DANZ cohort, and 13 years younger than the Selwyn cohort. The younger and healthier participants in the Alpert et al., (2009) study may have had a more efficient adaptive neuromuscular response to exercise, in contrast to the older participants of the current study.

The lack of change in sway should be interpreted with caution because of the low number of participants in the current study. Further, it is not clear how sway contributes to fall preventative research as ‘healthy’ and ‘unhealthy’ sway has not been established nor has sway been shown to be associated risk factor of falling. For future fall preventative dance studies to be of clinical relevance, future studies should investigate if impaired sway is a risk factor of falling and if so to what degree.

4.1.6 Study limitations

Some evidence has been presented from this double-cohort pilot study to demonstrate that participation in a mobility dance class or folk dance class can reduce risk factors for falling. However, in interrupting the results and drawing conclusions, several study design limitations need to be acknowledged. The current study was limited in the following ways:
a) While a reduction in risk factors for falling were observed in the current study, the outcome measures are indirect estimates and direct causal inferences should not be made about changes in prevention of falls. Direct outcome measures (e.g. number of falls prevented) is a more accurate way to measure fall prevention but due to time and cost restraints were not possible to implement for the current study.

b) The self-enrolment process of the current study may have attracted higher functioning participants, while low-activity high-falls-risk participants may have not enrolled themselves in the study. Participants chose which style of dance they undertook and therefore participants were not randomly assigned to an intervention. Therefore, generalisation of the current study’s findings to other groups, or the older population at large, should be made cautiously because it may not be a representative sample of the wider New Zealand older adult population.

c) Sample size was directly limited by venue sizes and the requirements to maintain a manageable instructor/participant ratio for safety reasons. This pilot study reports effect sizes that are of particular value in undertaking analysis of statistical power for future clinical trials. The low number of participants and different dance interventions meant that it was impractical to employ matched control participants from each cohorts living environment.

d) It appears from the high female to male ratio in the majority of dance studies that dance may attract females more so than their male counterparts. A limitation of the current study (and dance as a whole) is that few male participants enrolled. Therefore, conclusions from this study are primarily generalisable to the female population. Future studies should focus on a more balanced female/male ratio to investigate whether dance benefits are equal to that of females. Based on the lack of male participants in the majority of previous dance studies, it may be that dance is less appealing to older males and this may be worthwhile considering when implementing dance programs in the community setting.

e) The previous dance experience in the DANZ cohort precluded analysis of pooled data. The DANZ cohorts’ experience may have lead to an overestimation, or an
underestimation, of the magnitude of effect. The effect may have been overestimated from participants being able to perform more complex dance routines and gain associated benefits, or on the other hand, the outcome may have been underestimated from exercise adaptations taking place prior to baseline measures.

f) Despite a sway reliability study being conducted on adult’s using the Medicapteurs Sway-plate, many of the participants found it challenging to stand still on the small plate for 60 s without moving or talking and may have contributed to the high variance in the sway outcomes. A sway reliability study on older adults may be beneficial or, the use of a more sophisticated sway-platform of the type used in gait laboratories may be more user friendly for older adults.

g) Fall preventative benefits of dance should be compared to other commonly implemented interventions. In New Zealand it would be of interest to determine whether dance is comparable to the Modified Tai Chi classes and the Otago Exercise Program that is currently available to the paying New Zealand older adult public.
5.0 Conclusion

This double-cohort pilot study provides evidence that participation in a weekly mobility-dance class, or folk-dance class, is effective at reducing risk factors for falling in independent community-dwelling and retirement village-dwelling New Zealand older adults. Specifically, the risk factors for falling that improved in both cohorts were muscular endurance of the lower extremity and multidirectional dynamic gait and balance. These variables influence the risk of falling and therefore it may be inferred that dance might be an effective fall preventative intervention. However, until future dance studies are conducted measuring direct fall outcomes, dance cannot be claimed to be a fall preventative intervention. Nonetheless, the current study provided evidence of an exercise intervention that may appeal and be physically suitable for older adults and reduce risk factors for falling. Therefore the findings of the current study may warrant further investigation into the direct effect dance has on falls and compare these results to the current New Zealander fall preventative initiatives.

6.0 Conflict of interest

None.
7.0 References


58


SECTION THREE: Appendices
Appendix A: Physical outcome measures
Physical outcome measures

Participants were required to complete a 5-15 minute warm-up prior to data collection. A demonstration was performed before each measurable outcome with each participant being instructed to ‘do your best and never push themselves to a point of overexertion or beyond what you think is safe’ (Rikli & Jones, 1999).

a) 30 s Seated chair stand (30s SCS)
Lower body strength was recorded with a 30 s chair stand (30 s SCS) (Jones et al., 1999). The protocol began with the participant sitting on a secured chair (approximately 43 cm high) with no arm rests. The participant’s heel of the dominant foot was placed on the toe of the non-dominant foot then widened to shoulder width with arms crossed at the wrist and held against their chest (Jones et al., 1999). The participant performed three practise repetitions with correct form. On the signal ‘go’ the participant stood and sat down as many times as they could within 30 s without moving their feet. The total number of stands executed correctly within the 30 s period was counted and the final score taken from the average of three trials. If a participant was more than half way up in a squat when the 30 s elapsed, this was counted as a full stand. Sufficient rest time, (45 s – 60 s) was allowed between sets for muscular recovery, which has not been specified in reliability studies (Jones et al., 1999).

b) Single leg stand (SLS)
Static balance was measured with the single leg stand (SLS) (Miotto et al., 1999). Participants were instructed to "stay balanced as long as you can without moving your arms, taking a step or touching the ground with the other foot.” Participants held their arms crossed at the wrist and against their chest, and the timer was started once they raised their non-preferred foot off the ground by flexing their hip to a comfortable position (Miotto et al., 1999). Patients practised the measureable outcome twice on each leg to help them choose which leg they prefer to be tested on. The outcome was repeated with shoes on, three times with a 20 s – 30 s break in between and the average of the three times taken as the final score. There was a maximum time limit of 30 s and the timer was
stopped if any of the following occurred a) arms moved off their chest, b) the planted foot moved from the starting position, or c) the opposite foot in the air touched the ground (Kyaguchi & Furutani, 1998).

c) Four square step test (FSST)

Multi-directional dynamic gait and balance was recorded using the Four square step test (FSST) (Whitney et al., 2007). The protocol required the participant to step in sagittal and frontal planes. Two pieces of foam, one meter in length, were taped to the ground in a ‘plus sign’ (+). Each participant started with both feet flat on the ground in the bottom left corner facing forward with their feet together. Participants were required to move in a clockwise direction around the plus sign (forward, to the right, backward then to the left), returning to the starting position and then reverse the sequence back to the original starting position. At least one part of each foot had to touch down in each section. Participants were instructed to “try to complete the sequence as fast and safely as possible without touching the pieces of foam while facing forward during the entire sequence”. Participants performed one practice trial, followed by three recorded timed trials. The times of three correctly completed sequences was taken as the final score.
Appendix B: Supplementary results table
Table 2a: Results presented as parametric data for both cohorts pre-and post-intervention.

<table>
<thead>
<tr>
<th></th>
<th>Pre-intervention (mean ± SD)</th>
<th>Post-intervention (mean ± SD)</th>
<th>Mean Difference</th>
<th>95% CI for Difference</th>
<th>p-value</th>
<th>Effect size [2]</th>
<th>Descriptor [3]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DANZ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30s seated chair stand (freq)</td>
<td>10.0 ± 2.4</td>
<td>11.2 ± 3.1</td>
<td>1.2</td>
<td>-1.0</td>
<td>.01</td>
<td>0.04 [1]</td>
<td>Moderate</td>
</tr>
<tr>
<td>Single leg stance (s)</td>
<td>15.1 ± 7.3</td>
<td>19.3 ± 7.9</td>
<td>4.2</td>
<td>-8.0</td>
<td>.2</td>
<td>0.03 [1]</td>
<td>Large</td>
</tr>
<tr>
<td>4-square Step Test (s)</td>
<td>11.2 ± 2.9</td>
<td>8.9 ± 2.1</td>
<td>2.1</td>
<td>1.0</td>
<td>4.0</td>
<td>0.01 [1]</td>
<td>Large</td>
</tr>
<tr>
<td><strong>Selwyn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30s seated chair stand (freq)</td>
<td>10.5 ± 9.8</td>
<td>11.8 ± 2.7</td>
<td>1.3</td>
<td>-2.2</td>
<td>-0.3</td>
<td>0.01 [1]</td>
<td>Trivial</td>
</tr>
<tr>
<td>4-square step test (s)</td>
<td>11.2 ± 2.7</td>
<td>9.7 ± 2.6</td>
<td>1.5</td>
<td>0.1</td>
<td>3.0</td>
<td>0.03 [1]</td>
<td>Large</td>
</tr>
</tbody>
</table>

Notes:
[1] Significant at the 5% level
[2] Effect sizes were derived by mean difference divided by pre-standard deviation.
[3] Scale of magnitude was evaluated using the Hopkin’s effect size descriptors (W. G. Hopkins, 2002).

Data from both cohorts. Data in Table 2a did not violate assumptions of skewness or kurtosis (>1.96) or the Kolmogorov-Smirnov and Shapiro-Wilk test (>0.05) and therefore is presented as parametric data. Data in table 2b violated assumptions and therefore is presented as non-parametric data with Medians and IQR.
Table 2b: Results presented as non-parametric data for both cohorts pre- and post-intervention.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DANZ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sway length of path (mm)</td>
<td>188.2</td>
<td>180.1</td>
<td>163.3</td>
<td>163.0</td>
<td>-28.0</td>
<td>77.1</td>
<td>0.18</td>
<td>0.13</td>
</tr>
<tr>
<td>Sway area (mm(^2))</td>
<td>121.0</td>
<td>189.3</td>
<td>83.9</td>
<td>116.0</td>
<td>-40.2</td>
<td>112.0</td>
<td>0.27</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Selwyn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sway length of path (mm)</td>
<td>102.6</td>
<td>48.4</td>
<td>117.2</td>
<td>49.0</td>
<td>-34.4</td>
<td>17.2</td>
<td>0.25</td>
<td>0.18</td>
</tr>
<tr>
<td>Sway area (mm(^2))</td>
<td>30.0</td>
<td>35.7</td>
<td>28.5</td>
<td>44.7</td>
<td>-15.1</td>
<td>32.3</td>
<td>0.47</td>
<td>0.18</td>
</tr>
<tr>
<td>Single leg stance (s)</td>
<td>10.0</td>
<td>9.8</td>
<td>13.5</td>
<td>12.1</td>
<td>-8.0</td>
<td>1.0</td>
<td>0.14</td>
<td>0.35</td>
</tr>
</tbody>
</table>

[1] Significant at the 5% level
[2] Effect sizes were derived by mean difference divided by pre-standard deviation.
[3] Scale of magnitude was evaluated using the Hopkin’s effect size descriptors (W. G. Hopkins, 2002).
Appendix C: Ethic approval
Dear Rob,

Your file number for this application: 2011-1199
Title: The effects of a dance mobility program on physical functioning, self-perceived health status and balance confidence.

Your application for ethics approval has been reviewed by the Unitec Research Ethics Committee (UREC) and has been approved for the following period:

Start date: 20.7.2011
Finish date: 20.7.2012

Please note that:

1. The above dates must be referred to on the information AND consent forms given to all participants.

2. You must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.

You may now commence your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely,

Scott Wilson
Deputy Chair, UREC
25.8.2011

Re: Request for changes

Dear Catherine,

Your file number for this application: 2011-1199
Project Title: The Effects of a Dance Mobility Program on Physical Functioning, Self-Perceived Health Status and Balance Confidence.

Your request for changes to the above application have been reviewed by the Unitec Research Ethics Committee (UREC) and have been approved for the following period:

Start date: 20.7.2011
Finish date: 20.7.2012

Please note that:

1. The above dates must be referred to on the information AND consent forms given to all participants

2. You must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.

You may now continue your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely,

Scott Wilson
Deputy Chair, UREC

cc: Rob Moran
Dear Steve and Tania,

Your file number for this application: 2011-1248
Title: The Effects of a Dance Programme on Physical Functioning, Self-Perceived Health Status and Balance Confidence.

Your application for ethics approval has been reviewed by the Unitec Research Ethics Committee (UREC) and has been approved for the following period:

Start date: 15.12.2011
Finish date: 15.12.2012

Please note that:

1. The above dates must be referred to on the information AND consent forms given to all participants.

2. You must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.

You may now commence your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely,

Scott Wilson
Deputy Chair, UREC

cc: Catherine Bacon
Cynthia Almeida
Appendix D: Information sheet for participants
RESEARCH INFORMATION FOR PARTICIPANTS

The Effects of a Dance Programme on Physical Functioning, Self-Perceived Health Status and Balance Confidence

You are invited to participate in a research investigation that is running alongside the dance class which you’re already attending at Selwyn Village. Please read carefully through this information sheet and ask as many questions as you like before you make a decision about volunteering. Important: Choosing not to participate in the research doesn’t affect your ability to continue with the dance classes.

Who are the researchers?
Steven Chesterfield and Tania Russell are students entering the final year of a Master of Osteopathy degree at Unitec New Zealand and are the research investigators. Rob Moran and Dr Catherine Bacon are the research supervisors and lecturers within the Faculty of Health and Social Sciences at Unitec New Zealand (Mt Albert campus).

What is this study all about?
The main aim of the study is to investigate the effects of a dance mobility programme on several key risk factors for falling in older adults. The primary objectives are to determine if participating in a mobility-focused contemporary dance class once per week for nine weeks could improve:

1. Muscular endurance of the lower extremity and lower back
2. Multidirectional step coordination and balance
3. Single leg balance
4. Self-perceived health status
5. Self-perceived balance confidence

We will also be asking participants to rate their enjoyment levels at the end of the program on the dance program and if applicable, their enjoyment level of up to 5 other exercise forms that they may have previously participated in.
The characteristics we’re measuring have been linked to falling in older age groups and as the New Zealanders get older, preventing falls is an important consideration, both for the health and well-being of individuals but also for the associated economic impact. According to Statistics New Zealand (2009) the projected population aged 65 years and older will have increased from 13% in 2009 (550,000) to over 20% (over 1 million) in the late 2020’s in New Zealand. It has been estimated that 1 in 3 people over 65 years of age who live in the community fall at least once per year, and that 10-15% of those falls are associated with serious injury.

Keeping mobile and exercising has been proposed to reduce the risk of falls in older adults, and whilst exercise programs like Tai Chi and the Otago Exercise Program have been proven to reduce falls and are recommended by ACC in New Zealand, a variety of exercise options needs to be available to cater for individual preferences across a wide population. Dance programs have been shown to be effective in reducing falls and the risk of falls, however, to date there is limited research into dance programs in New Zealand.

By participating in this study you will help us to start investigating the role that dance programs like this one might have in preventing falls.

Who may participate?
Any person over the age of 65 who is attending the dance mobility programme is eligible to participate. Unfortunately, you will not be able to be participate in the study if you have difficulty understanding written or spoken English. Please feel free to contact the lead researcher (contact details below) if you are unsure about your eligibility.

What will happen in the study?
If you choose to participate in the study, here is what will happen:
At your first dance class, you will be asked to:
1. Carry out three physical tests after the warm-up period of dance and provide some basic information regarding your general health. This should take no more than 10 minutes, after which time you will re-join the dance class. These tests are designed to be no more physical than the dance class itself and consist of:

   - The first test is a 30 second Seated Chair Stand. You will start this test by sitting down in a chair with your arms folded in front of you. Once you been given the instructors to start a timer will begin. You are required to stand and return to your seated position as many times as possible until the times stops after 30 seconds at which point the instructor will let you know you may stop.

   - The second test is a Four Square Step Test. You are required to start in the bottom left corner and will move around in a clockwise direction making sure both feet touch in each square. (see appendix). Once you have returned to your starting position you will return in an anticlockwise direction back to where you
started from. This test will be times also and the instructor will let you know when you will start. You will be give a practise run through first followed by three timed trials.

- The last test is a single leg standing balance test. In this test you will be required to stand on preferred leg and lift the other leg out in front of you and hold the position for as long as you can or when 30 seconds is up, whichever is first. You will also be given the chance to figure out which leg you preferred to use and three timed tests will be taken.

2. Take home and fill out two questionnaires in your own time to be returned at the start of the next class. The first one asks you to rate your current level of health, including physical and emotional health, called the medical outcomes study 36-Item Short Form Survey Instrument (SF-36). The second one asks you to rate your level of confidence in being able to perform 16 tasks, you might come across in daily life, without falling, called the Activities-specific Balance Confidence Scale (ABC).

At your final dance class in week 9, you will be asked to repeat the above physical tests and be asked to take home the questionnaires to fill out again, returning the questionnaires in prepaid envelopes. There will also be an additional four-item questionnaire evaluating your enjoyment levels of the program and if applicable, your enjoyment levels of any previous exercise or movement program you may have participated in before.

**Discomforts/risks and benefits**
All of the physical measures taken during this study will be no more physical than the dance program itself. You will be guided through the tasks by the researcher with support from a research assistant where necessary. The tests will be re-explained to you at the time and you will be free to withdraw from participation in the study without reason at any time up until one week after the final week of class.

**What we do with the data and results, and how we protect your privacy.**
Personal information is collected and stored under the guidelines provided by the Privacy Act 1993 and the Health Information Privacy Code 1994. Your name will be recorded on the written consent form and the general health questionnaire. However, in all other instances of information collection your identity will remain anonymous and you will simply have an identification number. If the information you provide is reported or published, this will be done in a way that does not identify you as its source. All the data recorded will be stored securely and access to it will be limited to the principal researcher, the research supervisors, and yourself.

**Participation is voluntary**
The decision to participate in this study is totally voluntary. If at any time you feel uncomfortable you may inform the researcher and the measurement will be stopped immediately.
Your participation in this study will help to evaluate this dance mobility program and will provide a valuable addition to the ongoing research into exercise programs for the prevention of falls in older adults.

Please feel free to contact us at any time if you need further information about this study.

Contact Details
Stephen Chesterfield
Phone: 021 626 657
Email: chesterfieldsteve@hotmail.com

Tania Russell
Phone: 021 031 4198
Email: taniarussell@hotmail.com

UREC REGISTRATION NUMBER:
This study has been approved by the UNITEC Research Ethics Committee from 7th December 2011 to 6th December 2012 under ethics application number 2011-1248. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 6162). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix E: Participant consent form
PARTICIPANT CONSENT FORM

The Effects of a Dance Programme on Physical Functioning, Self-Perceived Health Status and Balance Confidence

This research project investigates a dance programme designed for older adults. We’re interested in knowing more about how your mobility and balance changes in response to dance.

Name of Participant: __________________________

I have seen the Participant Information Sheet and had the opportunity to read the contents and discuss the project with the primary researcher and I am satisfied with the explanations I have been given.

I consent to the researchers obtaining copies of the health status information that I provided to the class organisers prior to beginning the programme.

I understand that the anonymised data from the project will be held indefinitely for the purposes of future analysis and research.

I understand that taking part in this project is voluntary (my choice) and that I may withdraw from the project at any time prior to commencement of data analysis and this will in no way affect my access to the dance programme provided at Selwyn Village. I understand that I can withdraw from the study if, for any reason, I want to do so.

I understand that I can withdraw my data from the study at any time up until the date of the last data collection session.
I understand that the data recorded in this research project is confidential, and no material that could identify me will be used in any reports of this project. I acknowledge that any materials collected during the study will be stored securely so that only the researchers may access them. I understand that my data collection records will be made available on request. I understand that any data collected (i.e. measurements) will made anonymous and kept indefinitely to enable further analysis with data from other future studies. I have had enough time to consider whether I want to take part. I know whom to contact if I have any questions or concerns about the project. The principal researchers for this project are Steven Chesterfield and Tania Russell supervised by Dr Catherine Bacon and Rob Moran.

Rob Moran
Tel: 815 4321 x8197
Mob: 021 073 9984
Email: rmoran@unitec.ac.nz

Signature: _____________________________ (participant)
Date:________________

Project explained by researcher

Signature:_____________________________
Date:________________

The participant should retain a copy of this consent form.

UREC REGISTRATION NUMBER:
This study has been approved by the UNITEC Research Ethics Committee from 7th December 2011 to 6th December 2012 under ethics application number 2011-1248. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 7248). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix F: Enrolment form
Enrolment Form

Name: 

Address: 

Email: 

Phone Hm: Mobile: 

Emergency Contact Name: Phone: 

Age: 

Do any of the following apply to you? (please tick)
- I normally walk with an assistive device
- I have had a fall in the past 6 months (including a slip or trip in which you lost your balance and landed on the floor or ground or lower level)
- I am on four or more medications
- I have uncontrolled high blood pressure (over 160/100)
- I experience chest pain, dizziness or angina brought on by exercise
- My doctor has advised me not to perform cardiovascular exercise

Have you ever been diagnosed with any of the following? (please tick)
- Congestive heart failure
- Diabetes
- Stroke
- Parkinson’s Disease

This information is being collected for your safety. If you choose to take part in the optional research (by signing the separate consent form) this information may also be summarised for research purposes.

I agree to this information being used as stipulated above.

Signed: ____________________ Date: _______________
Appendix G: Medical history questionnaire
History Questionnaire

Name:

Age:

1. In the past 6 months, have you experienced any of the following? (please tick)
   - Ankle, knee or hip injury
   - Changes to the way you walk
   - Orthopaedic surgery of the hip, knee or ankle
   - Any change to the way you walk

2. Have you ever been diagnosed with any of the following? (please tick)
   - Head injury
   - Arthritis that requires management
   - Inner ear disease
   - Neurological disease
   - Vestibular disease (poor balance)
   - Nystagmus (abnormal eye movements)
   - Horner’s syndrome (consists of drooping upper eyelid, constricted pupil)
   - Eye disease, e.g. glaucoma
3. Do any of the following apply to you? (please tick)
   - I normally wear corrective glasses/lenses for seeing in the distance or reading
   - I normally use a hearing aid
   - I am on pain medication

4. In the past year, have you participated in any other movement/mobility programme or form of exercise?
   - Yes  
   - No

5. If Yes, please list each programme or exercise, your level of enjoyment of each, and if you currently still participate, how many days per week you take part.

<table>
<thead>
<tr>
<th>Exercise (e.g. Walking, Tai Chi)</th>
<th>Enjoyment level Enter a Number from 1-5: 1=do not enjoy at all, 5=enjoy immensely</th>
<th>How many days per week you currently take part Enter a Number from 1-7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I agree that the information from my Dance enrolment form may be used for analysis purposes as a part of this research in addition to the information collected in this questionnaire.

Signature: ___________________ Date: ___________________