Postural stability in older adults with mild to moderate cognitive impairment and Alzheimer’s disease

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Rhondda Davies, a dedicated proof reader.
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Abstract

Older adults with Alzheimer’s disease are at high risk of experiencing falls; their risk is double that of their healthy peers. The guidelines for achieving a fall risk reduction via an exercise-based intervention, for this population group, are unclear. Therefore, this thesis primarily aimed to develop, and to proof a concept of, an exercise-based intervention to improve postural stability as one means of reducing falls risk in older adults with mild to moderate cognitive impairment due to Alzheimer’s disease. A mixed methods study design was employed to achieve the study aim, via the following objectives: 1) to explore postural stability and the factors contributing to, or impacting on, postural instability in older adults with mild to moderate Alzheimer’s disease; 2) to identify and evaluate the psychometric properties of two commonly used clinical measures of postural stability (the Physiological Profile Approach and the Timed Up and Go test) for use in a proof of concept study of an exercise-based intervention; 3) to explore what older adults, with mild to moderate cognitive impairment due to Alzheimer’s disease, and their significant others, considered important to include in a sustainable and engaging exercise-based intervention; and 4) to proof a concept of the exercise-based intervention.

The systematic review (n = 18 studies) suggested that older adults with mild to moderate Alzheimer’s disease have reduced static and dynamic postural stability compared to their peers without cognitive impairment. The instability was mostly associated with activities that require attentional demand; for instance, dual task activities and when visual input is reduced (for example, activities with eyes closed).

A preliminary psychometric properties study (n = 13) suggested that falls risk screening, by the Physiological Profile Approach (moderate to good correlations rs = 0.604-0.745, p < 0.05; 33% sensitivity and 89% specificity) and the Timed Up and Go test (moderate to good correlations rs = 0.548-0.719, p < 0.05; 75% sensitivity and 67% specificity), might
be appropriate to measure postural instability and predict falls risk in older adults with cognitive impairment for both research and clinical purposes. Both tests are feasible to be used in a community setting.

Qualitative semi-structured interviews, conducted with 10 older adults with cognitive impairment and 7 support people, suggested that factors that might optimise delivery and engagement in exercise were: 1) having the choice of an individual- or a group-based exercise programme; 2) that exercise should be enjoyed and be pleasurable; 3) that exercises should stimulate brain activity; 4) that a support system is necessary; 5) that the programme should be of short duration; and 6) that the programme should include complex activities (e.g. dual task) that challenge their postural stability. These factors are however contingent of the understanding that while people living with cognitive impairment perceive that exercise is beneficial, as their cognition declines, a cyclic process of 1) awareness; 2) denial; 3) acceptance; and 4) coping strategies, influences decisions and degree of exercise engagement.

Based on these three preliminary studies, “Balance Wise”, an exercise-based intervention, was designed and tested among older adults with memory loss (group-based n = 9, individual-based n = 1) in a feasibility case series. It was conducted for 30 minutes once a week. To measure falls risk and postural stability, the Physiological Profile Approach, the Timed Up and Go test [basic], the Timed Up and Go test [cognitive] and the Step Test were used. The Timed Up and Go test [cognitive] and the Step Test were added to test attentional demand in dual task activity and postural stability in standing respectively. “Balance Wise” was found to be feasible, accepted, practical and safe to be conducted among older adults with memory loss. Most participants chose to join the group-based option. Improvements in functional postural stability performance and dynamic stability, measured by the Timed Up and Go test [basic] (turning to non-dominant side p < 0.05, r = -0.79; turning to dominant side p < 0.05, r = -0.82 and the Step Test (p < 0.05, r = -0.81), respectively, were demonstrated. Dropout was 5 out of 15 participants. Adherence was from 10% to 100% of 10 sessions of interventions.
Findings from systematic reviews (Chapter 4, study 1) found strong evidence for justifications of the need of an intervention study to improve postural stability and risks of falling. The findings derived from study 2 to 4 (Chapter 6 to 7) should be interpreted with caution because of their limitations such as small sample size and heterogeneous of the population being studied. Therefore it limits the applicability of the findings to be transferred for practise. The recruitment was challenging. This difficulty may be related to the cyclical process of denial and level of acceptance identified in the qualitative study. Even though, the thesis began by targeting older adults with mild to moderate cognitive impairment due to Alzheimer’s disease, participation by adults categorised in this way was found to be almost impossible to achieve. So, during the thesis, the target group evolved to become older adults with self-declared memory loss (with or without diagnostic evidence).

The data synthesising and integration of the findings highlighted a few considerations for an intervention targeting older adults with memory loss: 1) support systems are required, not only for older adults with memory loss, but also for their support person; 2) the higher the complexity of the activity, the more difficulty older adults, with cognitive impairment, have to execute it; those who have more severe cognitive impairment need supported one-to-one based exercise; and 3) supported and uninfluenced decision making is required to protect the autonomy of older adult with cognitive impairment.

Therefore, this thesis suggests the need for further exploration in the recruitment strategies of this vulnerable group of the population. For those who need one-to-one based exercise, the cost effectiveness of such an intervention will need to be evaluated in future studies. It is also recommended that physicians should use standardised tools to diagnose Alzheimer’s disease especially in the early phase of declining of cognitive function. Until these strategies are in place, researching postural stability to reduce risks of falling among older adults with Alzheimer’s disease in New Zealand is impossible due to the lack of specificity with such a broad terminology and spectrum of diseases presentation.
Publication and presentations


Oral presentations:

Falls prevention programme: What exercise characteristics matter to older adults with mild to moderate cognitive decline, 14-25 May 2016; Watch your step, 2016 National Fall Prevention Conference: Applying Integrated Approaches, Coast Plaza Hotel & Conferences, Calgary, Alberta, Canada.


Poster:

Fall prevention programme: What exercise characteristics matter to older adults with memory loss, 13th November 2015, Southern Physiotherapy Symposium, Queenstown, New Zealand.
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## Abbreviations

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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AD</td>
<td>Alzheimer’s disease</td>
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<tr>
<td>AUC</td>
<td>Area under the curve</td>
</tr>
<tr>
<td>BOS</td>
<td>Base of support</td>
</tr>
<tr>
<td>COM</td>
<td>Centre of Mass</td>
</tr>
<tr>
<td>COP</td>
<td>Centre of Pressure</td>
</tr>
<tr>
<td>EC</td>
<td>Eyes closed</td>
</tr>
<tr>
<td>EO</td>
<td>Eyes open</td>
</tr>
<tr>
<td>MCI</td>
<td>Mild Cognitive Impairment</td>
</tr>
<tr>
<td>mCTSIB</td>
<td>modified Clinical Test of Sensory Integration and Balance</td>
</tr>
<tr>
<td>MMSE</td>
<td>Mini Mental State Examination</td>
</tr>
<tr>
<td>OEP</td>
<td>Otago Exercise Programme</td>
</tr>
<tr>
<td>PPA</td>
<td>Physiological Profile Approach</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised Controlled Trial</td>
</tr>
<tr>
<td>ROC</td>
<td>Receiving Operator Curve</td>
</tr>
<tr>
<td>SAYGo</td>
<td>Steady As You Go</td>
</tr>
<tr>
<td>TUG [B]</td>
<td>Timed Up and Go basic</td>
</tr>
<tr>
<td>TUG [C]</td>
<td>Timed Up and Go cognitive</td>
</tr>
<tr>
<td>TUG</td>
<td>Timed Up and Go</td>
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# Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>Alzheimer’s disease</td>
<td>Acquired persistent compromise in intellectual function with impairments in at least three of the following components of mental activity, namely, language, memory, visuospatial skills, personality, and cognition (Cummings, Benson, &amp; LoVerme, 1980) which have a substantial effect on daily function (McKhann et al., 1984).</td>
</tr>
<tr>
<td>Dementia</td>
<td>Dementia is a chronic decline in cognitive function that causes impairment relative to a person's previous level of social and occupational functioning (Gouras, 2014).</td>
</tr>
<tr>
<td>Fall</td>
<td>An unexpected event in which the person comes to rest inadvertently on the ground, floor, or other lower level (Lamb, Jørstad-Stein, Hauer, &amp; Becker (2005), p. 1618). A fall can also be defined as an unintentional loss of balance that leads to failure of postural stability (Abreu &amp; Hartley (2013), p. 100).</td>
</tr>
<tr>
<td>Functional limitations</td>
<td>Deficits in the ability to perform discrete tasks such as climbing stairs. A functional limitation is clinically significant if it impairs ability to engage in physical activity.</td>
</tr>
<tr>
<td>Healthy peers</td>
<td>A group of older adults with a similar age range as the older adults studied in this thesis but without cognitive impairment.</td>
</tr>
<tr>
<td>Impairments</td>
<td>Also termed ‘deficits’, these refer to abnormalities at the level of tissues, organs, and body systems.</td>
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<tr>
<td>Mild Cognitive Impairment</td>
<td>The transitional state of cognitive change from normal ageing to dementia (Matthews et al., 2008).</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<td>---------------------------</td>
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<tr>
<td>Self-declared memory</td>
<td>Also termed ‘preclinical memory loss’, the difficulty in memory on an everyday basis that the person themself decides and declares is affecting them.</td>
</tr>
<tr>
<td>n</td>
<td>Number in sub-sample.</td>
</tr>
<tr>
<td>N</td>
<td>Total number in sample.</td>
</tr>
<tr>
<td>Older adults</td>
<td>Adults aged 65 years or older (55 years or older if Māori or Pacific Island). The difference in the age between groups is due to an ethnic health variance (Blakely et al., 2005).</td>
</tr>
<tr>
<td>Retirement village</td>
<td>Accommodation for persons 55 years or older, or retired from full-time employment, who are eligible to receive services which differ from aged care by legal contract.</td>
</tr>
<tr>
<td>Whānau</td>
<td>An extended family or community of related families who live together in the same area. This is a commonly used Māori word; the Māori language (te reo) is an official language in New Zealand.</td>
</tr>
<tr>
<td>Otago Exercise Programme</td>
<td>A home-based programme which aims to prevent falls in older adults aged 60 years and above, and includes individually tailored lower limb strength and balance retraining exercises.</td>
</tr>
<tr>
<td>SAYGo</td>
<td>Peer-led, group-based, exercise programme which was adapted from the OEP.</td>
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CHAPTER 1

Introduction

1.1 Introduction

This first chapter provides an outline and framework for the development of the research described in this thesis. It provides a guide to the overview of the thesis, clarification of the key terms, and the main aim of the thesis. Finally, the thesis style and layout with a brief overview of each chapter are described.

1.2 Overview of the thesis

Alzheimer’s disease (~50%) is the most common type of dementia (Hendrie, 1998; Plassman et al., 2007). Alzheimer’s disease can be described as an acquired progressive decline in intellectual function where at least three of the components of mental activity are impaired, namely language, memory, visuospatial skills, personality, and cognition (Cummings et al., 1980), and the condition substantially affects daily function (American Psychiatric Association, 1980; Lane, Hardy, & Schott, 2018; McKhann et al., 1984; World Health Organization, 2004).

Older adults with Alzheimer’s disease are at high risk of experiencing falls (ranging from 2 to 8 times greater risk, with incidence rates of 20-65% within a year) (Allan, Ballard, Rowan, & Kenny, 2009; Ballard, Shaw, Lowery, McKeith, & Kenny, 1999; Bassiony et al., 2004; Borges, Radanovic, & Forlenza, 2015; Tinetti, Speechley, & Ginter, 1988). Management following a fall in the Alzheimer’s disease population incurs a high cost; it is costlier than other conditions that cause falls (Alzheimer's Association, 2009, 2017; Bynum et al., 2004; Koppel, 2002; Rice et al., 2001; Zhao, Kuo, Weir, Kramer, & Ash, 2008; Zhu et al., 2006; Robertson, Devlin, Gardner, &
Management includes hospitalisation, medications, long term care and support groups (Bynum et al., 2004; Perracini & Ramos, 2002; Rice et al., 2001; Rubenstein, Josephson, & Robbins, 1994; Thapa, Brockman, Gideon, Fought, & Ray, 1996; Tinetti et al., 1988; Zhao et al., 2008). Consequently, falls among older adults with Alzheimer’s disease is an alarming issue for health policy makers, health care providers and for many levels of personnel involved, including family members (Alzheimer’s Association, 2015, 2016, 2017).

There are numerous, often multi-factorial, and complex reasons why older adults with AD fall frequently. Falls may occur due to poor lighting (Figueiro, Gras, Rea, Plitnick, & Rea, 2011), environmental hazards (Cumming et al., 1999) and diseases (Barnes & Yaffe, 2011; Cooper, Sommerlad, Lyketsos, & Livingston, 2015) or it could be due to the effect or interaction from consumption of multiple medications (Neutal, Perry & Maxwell, 2011). However, postural instability is also associated with falls risk (Suttanon et al. 2012) and this is the focus of this thesis.

Currently, there is no specific fall prevention guideline for this population group (Avin et al., 2015; Kenny et al., 2011; Nelson et al., 2007) and there is a lack of robust evidence to inform such a guideline (Abreu & Hartley, 2013; Claire, Isabelle, Hélène, & Nicolas, 2016; de Andrade et al., 2013; Hernandez, Coelho, Gobbi, & Stella, 2010; Kim et al., 2016; Öhman et al., 2016; Padala et al., 2017; Ries, Hutson, Maralit, & Brown, 2015; Suttanon et al., 2013a). One systematic review suggests that interventions that focus on postural stability have the potential to reduce falls among older adults with cognitive impairment (Suttanon, Hill, Said, & Dodd, 2010). Additionally, current literature suggests the inclusion of multi-type exercises, targeting flexibility, strength, balance and aerobic training (Gillespie et al., 2012; Kenny et al., 2011; Li et al., 2016; Nelson et al., 2007; Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011). However, are these the appropriate exercise components to address the risk of falls and improve postural stability among older adults with Alzheimer’s disease? Currently, the evidence is too sparse to answer this question.
Therefore, this thesis was inspired by current gaps in knowledge, specifically: 1) it is not known why older adults with Alzheimer’s disease have postural instability; and 2) whatever the reason, it is not known what best practice intervention is needed to reduce the risk of falls among older adults with Alzheimer’s disease. I wished to develop an exercise-based intervention to improve postural stability and reduce falls in older adults with Alzheimer’s disease. Based on previous work done to develop such interventions for older adults, I knew that this intervention could be considered as ‘complex’, namely because it would be an intervention with several interacting components. Therefore, I employed the process described by the United Kingdom Medical Research Council in developing a complex intervention. This thesis comprises phase one, the development phase, which includes: (1) Identifying the evidence base; (2) Identifying / developing theory; and (3) Modelling processes and outcomes (Campbell et al., 2007; Craig et al., 2008). I identified three areas that needed to be addressed before I could develop and evaluate the intervention, and these areas are discussed below.

Firstly, there is limited evidence as to what contributes to postural instability in older adults with Alzheimer’s disease and, thus, as to what factors need to be targeted to improve postural stability. Current evidence in this area focusses on dementia and cognitive impairment and does not focus specifically on Alzheimer’s disease (Härlein, Dassen, Halfens, & Heinze, 2009; Hartikainen, Lönnroos, & Louhivuori, 2007; Horak, 2006; Kearney, Harwood, Gladman, Lincoln, & Masud, 2013; Moreland, Richardson, Goldsmith, & Clase, 2004; Muir, Gopaul, & Montero Odasso, 2012; van Doorn et al., 2003). To address this area, I undertook a systematic review.

The second issue was what outcomes measures of postural instability I could use, to evaluate the newly developed intervention. Such outcome measures would need to be not only psychometrically robust, but also easily used in a community setting with older adults with Alzheimer’s disease. In addition, the measure should be quick and easy to apply, yet target a number of components of postural stability (Horak, 2006). Two suggested clinical measures to evaluate postural instability are the Physiological Profile Approach (PPA) and the Timed Up and Go (TUG) test. In depth discussion is presented in Chapter 2. Presently, there is limited psychometric data on the PPA
(Lorbach, Webster, Menz, Wittwer, & Merory, 2007; Taylor, Lord, Delbaere, Mikolaizak, & Close, 2012) and TUG test, in particular on concurrent validity, (Ries, Echternach, Nof, & Blodgett, 2009; Suttanon et al., 2012a; Tappen, Roach, Buchner, Barry, & Edelstein, 1997) to evaluate fall risk and postural stability in older adults with Alzheimer’s disease (Pardasaney et al., 2013). Most previous studies have been done among older adults without Alzheimer’s disease. I, therefore, in my second study, I aimed to validated both these measures.

A third area of concern was the paucity of research exploring the important characteristics of an exercise programme to optimise engagement and adherence from the perspective of older adults with Alzheimer’s disease (Cedervall & Åberg, 2010; Chong et al., 2014; Malthouse & Fox, 2014; Suttanon, Hill, Said, Byrne, & Dodd, 2012; Yu & Swartwood, 2012). There was also insufficient evidence of the best way to deliver such an intervention for this population (Öhman et al., 2016; Padala et al., 2017; Rolland et al., 2007; Suttanon et al., 2013a). Further to this, even if an exercise-based intervention was defined and shown to be of benefit, getting older adults with Alzheimer’s disease to engage in it sufficiently, in terms of intensity, frequency and duration, to improve postural stability, may be challenging. Older adults with Alzheimer’s disease require support from family members to complete everyday tasks (Charness & Holley, 2001; Edvardsson, Fetherstonhaugh, & Nay, 2010; Forde & Humphreys, 2002; Giovannetti et al., 2007) and, thus, support people / family members are central to their care. My third study, therefore, was a qualitative study in which I explored the concepts of postural instability awareness and of optimising intervention engagements with older adults with Alzheimer’s disease and their significant others.

I must note here that this thesis initially focused on Alzheimer’s disease. However, during the second study of this thesis Chapter 5 (the psychometric properties study), I ran into a major challenge with recruiting participants with Alzheimer’s disease. I consulted further with staff at the Otago branch of the Alzheimer’s Society and with a manager of a dementia care residential unit about this problem. As the city, that I was conducting this research in, only has a population of about 126,000 and at the time had no Memory Clinic or Dementia Clinic, these people strongly recommended that I
broaden my participant base to include older adults with mild to moderate cognitive impairment due to dementia. (The progression of an individual from normal cognition due to ageing process to dementia can be found at section 1.3). They suggested that the phrase I used in recruitment strategies be changed to older adults with “self-declared memory loss”. This thesis defined a person with “self-declared memory loss” as a person who self-claims to have difficulty remembering on an everyday basis or as having pre-clinical memory loss (Hampel & Lista, 2016). As a result, the text of the first section of this thesis, from Chapters 2 to 4, pertains to Alzheimer’s disease and the later part, from Chapter 5 onward, uses the terminology of “self-declared memory loss”. I discuss the reason for poor recruitment and the terminology used more fully in Chapter 5. Further discussion related to Alzheimer’s disease and its level of cognitive impairment can be found in Chapter 2. Clarification of the stage of dementia can be found below: (1) preclinical or pre-symptomatic of memory loss; (2) prodromal or Mild Cognitive Impairment (MCI) (Hampel & Lista, 2016); and (3) mild to moderate cognitive impairment.

1.3 Clarification of the stage of dementia

The first stage in the development of dementia is the “preclinical or pre-symptomatic memory loss” stage (Hampel & Lista, 2016). This refers to changes to cognition that occur as part of the normal process of ageing. Older adults aged 65 years and above frequently report forgetfulness and difficulty in recalling names of common places. This does not necessarily mean that the older adult has cognitive impairment, especially if their general intellect is preserved and they have no significant signs of impairment in everyday activities. At about the age of 65 years, the frontal, parietal and temporal regions of the brain begin to atrophy and this can cause changes in its memory performance of daily activities (Kirk-Sanchez & McGough, 2014). Research suggests that the first sign of “normal” ageing is associated with deficits in effortful memory (Craik, 1994; Light, 1991; Smith, 1996) and executive control (i.e. deficits in that part of the brain that is responsible for managing memories, for taking actions based on task-specific goals and for having thoughts that require effort to have) (Anderson, Jacobs, & Anderson, 2010; Hasher, Lustig, & Zacks, 2007; M. Hogan, 2005; Salthouse, 2005; West, Coleman, Flood, & Troncoso, 1994). These changes in cognition are
usually mild and this stage is known as the symptomatic memory loss stage (Hampel & Lista, 2016).

This stage is usually followed by the “prodromal or Mild Cognitive Impairment (MCI)” stage. MCI is the transitional state of cognitive change from normal ageing to dementia. (Matthews et al., 2008). Not all older adults with MCI progress on to dementia; about 44% of older adults with MCI will remain stable or even return to normal cognitive function over time (Ganguli, Dodge, Shen, & DeKosky, 2004; Ritchie, 2004). One meta-analysis found that 5-10% of older adults with MCI did not progress to dementia and approximately 10-18% did progress to dementia after 10 years of follow up (Kluger, Ferris, Golomb, Mittelman, & Reisberg, 1999; Mitchell & Shiri-Feshki, 2009; Petersen et al., 1999).

The third stage in the development of dementia is one of mild to moderate cognitive impairment. Dementia has been classified into three categories: mild, moderate and severe. These words are often interchangeably used with mild, moderate and severe cognitive impairment. Alzheimer’s disease is one type of dementia. In this thesis, “mild and moderate” were used to describe the stage of cognitive impairment in older adult with Alzheimer’s disease and those with self-reported memory loss. These categorisations are further explained in Chapter 2. The reasons of choosing mild to moderate cognitive impairment among older adults with Alzheimer’s disease are explained in Chapter 3. For the purpose of this thesis, mild to moderate cognitive impairment was measured using Mini Mental Scale Examination, where a score of 18-30 represents mild and 10-17, moderate cognitive impairment (Folstein, Folstein, & McHugh, 1975; Ries, Drake, & Marino, 2010; Shigemori, Ohgi, Okuyama, Shimura, & Schneider, 2010).

1.4 Main aim of the thesis

The thesis aimed to develop and evaluate, a proof of concept exercise-based intervention to improve postural stability as one means of reducing falls risk in older adults with mild to moderate Alzheimer’s disease.
To address this aim, the development of the intervention followed the steps outlined by the United Kingdom’s Medical Research Council for developing a complex intervention (Campbell, Fitzpatrick, Haines, & Kinmonth, 2000; Craig et al., 2008). Thus a number of preliminary steps were required to identify what the intervention should comprise and how to evaluate change in postural stability in the target population group.

To achieve these steps, four objectives were set:

1. To identify whether older adults with mild to moderate Alzheimer’s disease have reduced postural stability and the factors associated with postural instability in older adults with mild to moderate Alzheimer’s disease. This objective was achieved with a systematic review.

2. To identify and evaluate the psychometric properties of the clinical measures of postural stability for use in the proof of concept study. The measures subsequently identified were the Physiological Profile Approach and the Timed Up and Go Test. This objective was met by conducting a laboratory-based psychometric study.

3. Explore what older adults with mild to moderate Alzheimer’s disease and their significant others considered important to include in an exercise-based intervention to optimise sustained engagement. A qualitative study was undertaken to address this objective.

4. To develop and evaluate the acceptability, practicality, adherence, safety and potential benefits of the exercise-based intervention. A proof of concept study with a case series design achieved this objective.

1.5 Thesis layout

The flow of this thesis is presented as shown in Figure 1.1 below.

This thesis comprises 8 chapters:

• Chapter 1: This introductory chapter
• Chapter 2: The background and literature review underpinning this thesis
• Chapter 3: The description and rationale of the methodology used
• Chapter 4: The Systematic review
• Chapter 5: The psychometric study
• Chapter 6: The qualitative study
• Chapter 7: The proof concept of study
• Chapter 8: The overall thesis discussion
Figure 1.1 Flow of the thesis
1.5.1 Overview of the chapters

In Chapter 2, the relevant literature is reviewed to contextualise the thesis and this includes: definitions of Alzheimer’s disease; and discusses the complexity of diagnosis, the burden of the disease and its management; the impact of falls and the relationship between falls and postural stability; and current exercise recommendations for older adults with cognitive impairment.

Chapter 3 describes, with rationale, the methodology and methods used in this thesis, including: complex interventions and use of qualitative and quantitative data collection; philosophical and methodological considerations; the choice of a mixed methods design; and ethical considerations.

Chapter 4 reports the findings from my study of a systematic review which explored postural stability and the factors contributing to postural instability among older adults with Alzheimer’s disease. This study provided the target components of postural stability to be improved in the intervention.

Chapter 5 reports results from the study investigating the concurrent validity of three outcome measures: Physiological Profile Approach, the Timed Up and Go test and Dynamic Balance Posturography (selected as the “gold standard”); and the sensitivity and specificity of the Physiological Profile Approach and the Timed Up and Go test.

Chapter 6 reports the participants’ perspectives of what an ideal intervention delivery that could maximise adherence to the exercised-based intervention would be. The latter is presented in Chapter 7.

Chapter 7 reports on exercise-based intervention to improve postural stability, namely a case series proof of concept study to evaluate the intervention’s acceptability, practicality, adherence, safety and potential benefits. In addition, the viability and success of the recruitment process for this study were assessed.
Chapter 8 synthesises the findings from all studies and discusses five key points. This chapter also includes the practicality of the exercise-based intervention trialled in Chapter 7.
CHAPTER 2

Literature review

2.1 Introduction

Chapter 2 aims to provide a background overview of the relevant information related to the work presented in this thesis. This literature review will include studies of the current interventions to improve postural stability in older adults with Alzheimer’s disease. It starts with a review of current research regarding the epidemiology of Alzheimer’s disease, falls, and evaluation of the risk of falls. The strategies for falls prevention are then critiqued and discussed with respect to the current exercise recommendations to improve postural stability and to prevent falls in this population.

2.2 Alzheimer’s disease

Alzheimer’s disease is acknowledged as a complex, irreversible, progressive, multifactorial, neurodegenerative disorder, and is the most common type of dementia in late adult life (Dubois et al., 2010; Dubois et al., 2007; Hendrie, 1998; Plassman et al., 2007). The exact mechanism of the pathological changes for this disorder remains unclear. However, neurologists believe that, pathologically, Alzheimer’s disease relates to plaques in the elderly brain brought about by the deposition of intracellular neurofibrillary tangles and extracellular amyloidal protein (Dubois et al., 2010; Jack et al., 2010; Kumar, Singh, & Ekavali, 2015). After an interval of time, which varies from person to person, neuronal dysfunction and neurodegeneration become the dominant pathological processes and eventually lead to neuronal loss (Bokde, Ewers, & Hampel, 2009). These pathological changes in the brain interrupt the normal activation and connectivity of the brain region from one area to another within a specific neuronal network (Büchel, Coull, & Friston, 1999). Thus Alzheimer’s disease presents as a cognitive disorder, specifically in the domain of working memory, which affects central executive function (McCabe, Roediger III, McDaniel, Balota, & Hambrick, 2010).
Working memory is a system that provides temporary storage for the maintenance and manipulation of information that important for accomplishment of complex task in everyday life such as reasoning (Baddeley, 1992; McCabe et al., 2010; Miyake & Shah, 1999). Whereas, the central executive brain function plays a role for controlled processing within the working memory such as, a decision making, directing attention, retrieval of memory and maintaining task-specific goals ((McCabe et al., 2010), p. 2). In the early manifestation of Alzheimer’s disease, working memory is hypothesised to be significantly impaired. Further, in activities that require the performance of two tasks simultaneously, older adults with Alzheimer’s disease are particularly impaired (Baddeley, Bressi, Della Sala, Logie, & Spinnler, 1991; de Andrade et al., 2014; Manckoundia, Pfitzenmeyer, d'Athis, Dubost, & Mourey, 2006; Pettersson, Olsson, & Wahlund, 2005; Suttanon et al., 2012a). Older adults with Alzheimer’s disease may also have a delayed response of visuo-spatial memory (Alescio-Lautier et al., 2007; Simone & Baylis, 1997; Stuart-Hamilton, Rabbitt, & Huddy, 1988) which contributes to deficits in everyday skills such as, navigating self while walking (Perry & Hodges, 2000).

2.2.1 The prevalence and incidence of Alzheimer’s disease

Estimation of prevalence and the incidence of Alzheimer’s disease are important to calculate to ensure the availability of adequate resources to meet current and future healthcare needs. The latest report from the Alzheimer’s Association, USA was published in 2015 and the prevalence of Alzheimer’s disease worldwide was estimated to be 33.9 million and projected to increase to 101.7 million by 2046 (Alzheimer's Association, 2015). Most people with Alzheimer’s disease live in developing countries (Ferri et al., 2005). A delphi consensus study however reported that, while the rate of increment is high in developed countries (by 100% between 2001 and 2040), it is now even higher (300%) in developing countries (e.g., China and India) (Ferri et al., 2005). The incidence rate of the development of Alzheimer’s disease worldwide has been reported to be as fast as one person being diagnosed every 66 seconds and this rate is predicted to increase to a new case every 33 seconds by 2050 (Alzheimer's Association, 2016). With these rates, the prevalence is estimated to double every 20 years (Prince et al., 2013).
Fiest et al. (2016) conducted a meta-analysis on prevalence and incidence of reported Alzheimer’s disease in the community. In this study, the researchers pooled prevalence data from 119 studies. From 119 studies worldwide spanned Africa, Asia, North and South America, Europe and Australia. The prevalence of Alzheimer’s disease in older adults (age 60 years and above) living in the community was 40.19 per 1000 (CI 95%: 29.06, 55.59) while the pooled incidence rate was 15.8 (CI 95%: 12.9, 19.4) per 1000 person-years (Fiest et al., 2016). However, there were insufficient data to report on the prevalence and incidence rate of Alzheimer’s disease for institutional settings and thus to usefully compare these rates.

2.2.2 The diagnostic criteria for Alzheimer’s disease

There are well known systems used to diagnose and classify dementia and Alzheimer’s disease. Three which are used worldwide are: (1) Diagnostic and Statistical manual of Mental disorder (DSM), (2) the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (NINCDS-ADRDA) and (3) International Classification of Disease and Related Health Problems 10th Revision (ICD-10). This section will briefly discuss these three systems.

The American Psychiatric Association (APA) publishes the Diagnostic and Statistical manual of Mental disorder (American Psychiatric Association, 1980, 1987, 1994, 2013). The DSM provides diagnostic criteria tools for dementia or Neurocognitive Disorder (NCD) and a further 19 other mental health conditions. In 1980 the DSM defined dementia as adults “in which there is clear evidence of progressive and significant deterioration of intellectual and social or occupational functioning” (Serge Gauthier et al., 2006, p. 1262). The purpose of this diagnostic criterion by DSM is to provide a guideline to clinicians to differentiate between each of these 20 disorders (American Psychiatric Association, 1980). There is a much broader and not age- or Alzheimer’s disease (AD)-specific criterion (Eramudugolla et al., 2017). The most recent revision of the DSM, the Fifth Edition (DSM-V), was published in 2013 and now characterises those with Alzheimer’s disease as having memory and learning declines in addition to one other cognitive domain, steady gradual cognitive decline and no evidence of mixed aetiology (i.e., absence of cerebrovascular disease or other
condition or disease contributing to cognitive decline) ((Baker, 2016) p. 10) (American Psychiatric Association, 2013; Dubois et al., 2010; First, 2010). The DSM-V version also now includes criteria for the early detection and treatment of mild cognitive decline (or Mild Neurocognitive Disorder). In the other words, these criteria are to enable early detection of deficits before the condition becomes more distinct and progresses to dementia (Major Neurocognitive Disorder) or other devastating neurocognitive conditions (Eramudugolla et al., 2017).

Clinical criteria for the diagnosis of Alzheimer’s disease were established by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (NINCDS-ADRDA) (McKhann et al., 1984). These clinical criteria are importance to guide researchers and to describe multiple methods that would be beneficial for evaluate the natural history of Alzheimer’s disease (McKhann et al., 1984). This work resulted in guidelines to diagnose Alzheimer’s type of dementia in which it is stated ((McKhann et al., 1984) p. 940) that a person with Alzheimer’s disease should have impairments in two or more areas of cognition, with progressive declining of memory and other cognitive function (Gauthier et al., 2006; McKhann et al., 1984). In these guidelines, the assessment was based on many clinical and laboratory examinations such as medical history and neuropsychological testing. For instance, in neuropsychological tests, individuals might be at high risk to progress to dementia if they have a low performance in delayed recall and executive function subtests. This earlier version of NINCDS-ADRDA criteria was compatible with the definition provided by the Diagnostic and Statistical manual of Mental disorder-III (DSM-III) and the International Classification of Disease (ICD) with additional confirmation by autopsy (McKhann et al., 1984). The distinctive difference between criteria laid down by NINCDS-ADRDA and those by DSM is that the clinical criteria for Alzheimer’s disease do not involve evidence of interference within the context of social or occupational functioning (Baker, 2016; Dubois et al., 2007; McKhann et al., 1984). The DSM states that the onset of Alzheimer’s disease is insidious and that there is a lack of evidence that shows involvement of other systemic or brain diseases that may explain for the progressive declining in memory and other cognitive functions (Baker, 2016; Dubois et al., 2007; McKhann et al., 1984).
Therefore, to heighten the specificity of the diagnosis of Alzheimer’s disease within the pathophysiological context, in 2011 the National Institute on Aging and the Alzheimer’s Association organised an international workgroup to review the epidemiological, biomarker and neuropsychological evidence (Baker, 2016; McKhann et al., 2011). This revision was important to refine the more specific guidelines by determining the factors which sensitively and distinctly differentiate the risk of progression from “normal” cognition to Mild Cognitive Impairment and Alzheimer’s disease type of dementia (McKhann et al., 2011; Sperling et al., 2011).

In 1992, World Health Organisation published the International Classification of Disease and Related Health Problems 10th Revision (ICD-10): classification of mental and behavioural disorders. The ICD-10 defined Alzheimer’s disease as a condition, aetiology unknown, of degenerative cerebral disease with characteristic changes in neuropathological and neurochemical features of the brain (World Health Organization, 1992). The onset of the disorder is similar to that described in the DSM, which is insidious and that it progresses gradually over a period of time that might last several years (World Health Organization, 1992, 2015) (see chapter V, Mental and behavioural disorders, in the ICD-10 manual) (World Health Organization, 2004). The ICD-10 contains more general characteristic presentations for classifying Alzheimer’s disease (Quinn, 2013).

These three systems of diagnostic criteria, the Diagnostic and Statistical manual of Mental disorder (DSM), the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (NINCDS-ADRDA) and the International Classification of Disease and Related Health Problems 10th Revision (ICD-10) are widely used and remain benchmarks for clinicians and researchers when diagnosing Alzheimer’s disease and other dementia-related condition types (World Health Organization, 1992, 2015). However, there is a concerns regarding the diagnosis of Alzheimer’s disease which relate to the distinction between terms used in research. For example, the distinction between Mild Cognitive Impairment and Alzheimer’s disease is unclear. Researchers suggest that a more refined
A definition of Alzheimer’s disease is needed to accurately identify the presentation of the disease at the early stage (Dubois et al., 2007).

2.2.3 The level of cognitive impairment in Alzheimer’s disease

Information about the various stages of cognitive impairment in older adults with Alzheimer’s disease is needed to ensure that intervention is based on current and future needs. At present there are multiple tools to provide a brief, objective measure of cognitive function. Although there are a number of screening tests available, the Mini Mental State Examination (MMSE), published in 1975 (Folstein et al., 1975), has traditionally been the most commonly used (Chong, Horak, Frank, & Kaye, 1999; Chong, Jones, & Horak, 1999a; Dickin & Rose, 2004; Elble & Leffler, 2000; Franssen, Souren, Torossian, & Reisberg, 1999; Gras et al., 2015; Kato-Narita, Nitrini, & Radanovic, 2011; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot, Beauchet, Annweiler, Cornu, & Deschamps, 2014; Nakamura et al., 1997; Pettersson, Engardt, & Wahlund, et al., 2002; Suttanon et al., 2012a) (de Andrade et al., 2014). A new version, labelled the Mini Mental State Examination-II (MMSE-II), is under development (Mitchell, 2009). The original was developed for hospitalised clients and has been used widely by clinicians and researchers, in both community (Murden, McRae, Kaner, & Bucknam, 1991) and primary care settings (Anderson, Sachdev, Brodaty, Trollor, & Andrews, 2007; Jones & Gallo, 2000). Moreover, it serves as one of the recommended screening tools to measure cognitive function by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorder Association (NNCDS-ADRDA) as an additional measure for the diagnosis of probable Alzheimer’s disease (McKhann et al., 1984). Controversially, rights holders of the MMSE have recently started to sue on unauthorized use of this tool which has led some researchers to move to more recently developed tools (Feldman & Newman, 2013). Nevertheless, the MMSE is easy to use, non-specialists as well clinicians in primary care are able to administer it. To date the MMSE is available in many languages (Park, Jeon, Lee, Cho, & Park, 2017; Shim, Yang, Kim, Park, & Kim, 2017; Yang et al., 2016).
The MMSE has good test–retest reliability (0.80–0.95) (Folstein et al., 1975; O’Connor et al., 1989) (Tombaugh & McIntyre, 1992) and sensitivity (0.86) and specificity (0.92) in what the researchers involved defined as ‘organic mental disorders’ (O’Connor et al., 1989). Folstein et al. (1975) reported that the MMSE was highly test-retest reliable when it was measured over 24 hours ($r = 0.89$) and 28 days ($r = 0.99$) by single evaluators (Folstein et al., 1975). These authors also reported good inter-rater reliability for the examination ($r = 0.83$) when it was administered by two different evaluators 24 hours apart.

The MMSE has 17 individual questions with 7 domains covering visuospatial skills and praxis, calculation, short term memory, orientation, registration and attention (Folstein et al., 1975). Previous studies have investigated the relative contribution of the individual items that make up the MMSE by examining the factorial structure of results in both healthy participants and people with cognitive deterioration (Ashford, Kolm, Colliver, Bekian, & Hsu, 1989; Boer, Mattace-Raso, Steen, & Pel, 2014; Brooks et al., 1993; Brugnolo et al., 2009; Castro-Costa et al., 2014; Fillenbaum, Heyman, Wilkinson, & Haynes, 1987; Shigemori et al., 2010; Tinklenberg et al., 1990). The overall findings of these studies indicate that the MMSE items have differing degrees of difficulty and differing sensitivity to different cognitive impairments (Brugnolo et al., 2009). In addition, analysis of the MMSE shows that it could classify different cognitive profiles and understandings of the possible cognitive domains affected in older adults with Alzheimer’s disease (Noale, Limongi, & Minicuci, 2006). To assess the factorial structure of the MMSE, two types of factor analysis can be employed: 1) static MMSE score where the individual items of the examination were obtained from a single administered test to reflect the basic cognitive profile of study participants (Boer et al., 2014; Brugnolo et al., 2009; Carcaillon, Amieva, Auriacombe, Helmer, & Dartigues, 2009; Fillenbaum et al., 1987; Shigemori et al., 2010; Tinklenberg et al., 1990); and 2) dynamic MMSE score where the average rate of the MMSE score change over time was used to evaluate the rate of progression of Alzheimer’s disease and to provide valuable insight into the nature of Alzheimer’s disease (Brooks et al., 1993; Castro-Costa et al., 2014; Shigemori et al., 2010).
2.2.4 Risk factors for Alzheimer’s disease

Table 2.1 illustrates the risks and associated factors for developing Alzheimer’s disease. Alzheimer’s disease is not part of the normal ageing process (Hampel & Lista, 2016; Ohnishi, Matsuda, Tabira, Asada, & Uno, 2001). The development of Alzheimer’s disease is a progressive process and it is associated with multi-factorial risks.

Exploration of risk factors is important for developing prevention measures. Baumgart et al. (2015) extensively reviewed the risk factors for cognitive impairment in Alzheimer’s disease (Baumgart et al., 2015). These risk factors can be grouped under the headings of genetics, co-morbidity, lifestyle and low education (Baumgart et al., 2015). Histology studies found that inflammatory substances such as C-reactive protein interleukin-6 APOE epsilon4 Fe were associated with Alzheimer’s disease (Koyama et al., 2013; Loef & Walach, 2012; Purnell, Gao, Callahan, & Hendrie, 2009). The following conditions are also risk factors: Diabetes, which has a relative risk estimate of 1.39 (95% CI 1.17, 1.66) (Barnes & Yaffe, 2011; Biessels, Staekenborg, Brunner, Brayne, & Scheltens, 2006; Cooper et al. (2015); Kopf & Frolich, 2009); Hypertension, which has a relative risk estimate of 1.61 (95% CI 1.16, 2.24) (Barnes & Yaffe, 2011; Guerchet et al., 2011); and Depression, which has a relative risk estimate of 1.90 (95% CI 1.55, 2.33) (Barnes & Yaffe, 2011; Diniz, Butters, Albert, Dew, & Reynolds, 2013; Ownby, Crocco, Acevedo, John, & Loewenstein, 2006). In addition, one recent study found that influenza infections were also associated with the risk of Alzheimer’s disease in later life (Imfeld, Toovey, Jick, & Meier, 2016). There is also evidence to suggest that lifestyle factors maybe also be risk factors with a relative risk estimate range from 1.59 to 1.82 (95% CI 1.19, 2.78) (Barnes & Yaffe, 2011; Bernhardt, Seidler, & Frolich, 2002; Durazzo, Mattsson, & Weiner, 2014; Peters et al., 2008). The mechanism of action for most of the lifestyle-related risk factors, especially smoking, physical inactivity, depression, and obesity, were largely related to vascular disease (Barnes & Yaffe, 2011; Snowdon et al., 1997; Vermeer et al., 2003). Low education is also a risk factor with a relative risk estimate of 1.59 (95% CI 1.35, 1.86) (Ampil, Fook-Chong, Sodagar, Chen, & Auchus, 2005; Barnes & Yaffe, 2011; Beydoun et al., 2014; Borenstein, Copenhaver, & Mortimer, 2006; Sharp & Gatz, 2011). Low education was found to be associated with lower socio-economic status, which was in turn associated with poorer health and difficulty with accessing health services, thus
increasing the risk of Alzheimer’s disease (Keskinoglu, Giray, Picakcifefe, Bilgic, & Ucku, 2006; Nitrini et al., 2004; Scazufca et al., 2008).

Table 2.1 Risk and associated factors for Alzheimer's disease

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<tr>
<th>Attributes</th>
<th>Authors</th>
<th>Relative risk</th>
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<tr>
<td>Co-morbidity</td>
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<tr>
<td>Diabetes</td>
<td>Barnes and Yaffe (2011); Biessels et al. (2006); Cooper et al. (2015); Kopf and Frolich (2009)</td>
<td>1.39 (95% CI 1.17, 1.66)</td>
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<td>Hypertension</td>
<td>Barnes and Yaffe (2011); Guerchet et al. (2011)</td>
<td>1.61 (95% CI 1.16, 2.24)</td>
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<tr>
<td>Depression</td>
<td>Barnes and Yaffe (2011); Diniz et al. (2013); Ownby et al. (2006)</td>
<td>1.90 (95% CI 1.55, 2.33)</td>
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<tr>
<td>Lifestyle</td>
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<tr>
<td>Smoking</td>
<td>Barnes and Yaffe (2011); Durazzo et al. (2014); Peters et al. (2008)</td>
<td>1.59 (95% CI 1.15, 2.20)</td>
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<tr>
<td>Physical inactivity</td>
<td>Bernhardt et al. (2002)</td>
<td>1.82 (95% CI 1.19, 2.78)</td>
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<tr>
<td>Obesity</td>
<td>Barnes and Yaffe (2011)</td>
<td>1.60 (95% CI 1.34, 1.92)</td>
</tr>
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Notes. CI, confidence interval

2.2.5 Cost and institutionalisation among older adults with Alzheimer’s disease

Alzheimer’s disease is one of the costliest diseases in the community (Alzheimer's Association, 2009; Zhao et al., 2008; Zhu et al., 2006). For example, based on Medicare\(^1\) reports, patients with Alzheimer’s disease utilised health care resources, i.e. hospitalisation, 2 to 5 times higher (Bynum et al., 2004; Rice et al., 2001; Zhao et al., 2008), compared to patients with other illness who received the same healthcare benefits (Zhao et al., 2008). Based on the latest evidence, the cost keeps increasing (Alzheimer's Association, 2017). In the United States of America, the 2017 total cost for health care, long-term care, and hospital services, for older adults (age ≥65 years) with Alzheimer’s disease, was $259 billion compared to $121 billion 15 years ago.

\(^{1}\) A federal health insurance programme for older adults aged 60 years and above, with and/or without severe disability.
The cost of Alzheimer’s disease management is not only born by the individual concerned, but also affects their caregivers. The caregiver is central to the care and support of older adults with Alzheimer’s disease and, as a result, caregivers experience a huge amount of psychological and economic strain (Malthouse & Fox, 2014; Prince, 2004; Schneider, Murray, Banerjee, & Mann, 1999). Taking care of a person with Alzheimer’s disease is time consuming and some caregivers have to reduce work commitments or duration of working life, thus there is an economical impact on families (Alzheimer's Association, 2016). For example, in the United States of America, in 1998, the annual cost for informal care was $18 billion (Langa et al., 1998).
2001). This cost will proportionally increase with the incremental increases in the incidence of the Alzheimer’s disease (Langa et al., 2001).

2.3 Falls among older adults with Alzheimer’s disease

A fall is “defined as an unexpected event in which the person comes to rest inadvertently on the ground, floor, or other lower level” (Lamb et al. (2005), p. 1618). A fall can also “be defined as an unintentional loss of balance that leads to failure of postural stability” (Abreu and Hartley (2013), p. 100). As falls are one of the leading causes of impairment, and can also increase mortality in older adults with Alzheimer’s disease; strategies to reduce the risk of falls in this population are crucial (Rattinger et al., 2015). In this section, I discuss the prevalence, the risk factors for falling, and the impact of falls.

2.3.1 Prevalence and incidence of falls in older adults with Alzheimer’s disease

The prevalence of falls among older adults with Alzheimer’s disease who present with cognitive impairment is high in comparison with the rates occurring among healthy older adults (Carvalho & Coutinho, 2002; Perracini & Ramos, 2002; Tinetti et al., 1988). The literature has estimated the prevalence of falls has ranged from 2 to 8 times higher, with incidence rates ranging from of 20-65% within a year among older adults with cognitive impairment (Alexander et al., 1995; Allan et al., 2009; Ballard et al., 1999; Bassiony et al., 2004; Borges et al., 2015; Chong et al., 1999; Horikawa et al., 2005; Imamura et al., 2000; Pettersson et al., 2002; Salvà et al., 2012; Suttanon, Hill, Said, & Dodd, 2013; Whitney et al., 2005; Yasumura et al., 1994). Prevalence of falls for older adults with dementia varies considerably by setting. Older adults living in long term care facilities have a much higher rate in comparison with those living in the community (Rothschild, Bates, & Leape, 2000; Rubenstein et al., 1994; Thapa et al., 1996). This might be due to the higher level of frailty and ill-health among older adults living in long term care (Rubenstein et al., 1994). Furthermore, evidence shows that older adults who have a history of falls have 2 to 6 times the risk of future falls (Allan et al., 2009; Ballard et al., 1999; Härlein et al., 2009; Suttanon et al., 2013; Tinetti & Kumar, 2010) due to delayed recovery from a fall injury (Horan & Clague, 1999; Rubenstein, 2006) and post-fall anxiety syndrome (Alarcon, Gonzalez-Montalvo,
2.3.2 Falling risk factors, postural stability, and the association factors of postural instability in older adults with Alzheimer’s disease

Postural instability is one of the reasons older adults with Alzheimer’s disease fall (Mesbah, Perry, Hill, Kaur, & Hale, 2017). The factors associated with postural stability which cause instability among older adults with Alzheimer’s disease are not clear. Thus, a systematic review was conducted as part of this thesis to specifically present what evidence there may be, regarding these factors and these results are discussed in detail in Chapter 4.

2.4 Evaluating the risk of falling and postural stability

There are many tools that can be used to evaluate this risk and postural instability. They include both clinical-based tools (Hill, Bernhardt, McGann, Maltese, & Berkovits, 1996; Lord, Menz, & Tiedemann, 2003; Podsiadlo & Richardson, 1991) and laboratory-based tools (Allum, Carpenter, Honegger, Adkin, & Bloem, 2002; Henry, Fung, & Horak, 1998). Both types of tools have advantages and disadvantages, as discussed below. In previous studies, the outcome measures used to evaluate postural stability were inconsistent. As suggested by Howe et al. (2011), the outcome measures used to evaluate the changes of postural stability after a set of intervention should be consistent (Howe, Rochester, Neil, Skelton, & Ballinger, 2011). Recently a consensus statement was published on tools and measures that are most useful to evaluate postural stability (Sibley et al., 2015). However, outcome measures for my study was selected before the consensus was published in 2015. Thus I see it as a limitation of my study. Moreover, the applicability of this consensus to older adults with Alzheimer’s disease remains unclear (Sibley et al., 2015). Thus, in this discussion, I concentrate on the laboratory-based tool of posturography (used later as a “standard measure” in my thesis) and on the clinical-based tools of the PPA and the TUG test, as these latter two are pertinent to my thesis. I deliberately chose the PPA and the TUG tests as previous studies with older adults with Alzheimer’s disease had used these two measures more
frequently than other similar measures (Abreu & Hartley, 2013; Ahn & Kim, 2015; Claire et al., 2016; de Andrade et al., 2013; Hernandez et al., 2010; Liu-Ambrose, Ashe, Graf, Beattie, & Khan, 2008; Lorbach et al., 2007; Pedroso et al., 2012; Ries et al., 2010; Ries et al., 2015; Rolland et al., 2007; Suttanon et al., 2013a; Wesson et al., 2013). Moreover, there is a compelling suggestion to use both as an initial assessment of the risk of falling in clinical practice (Whitney et al., 2005). As both the PPA and the TUG test are simple, they are feasible for use in community settings.

2.4.1 Computerised posturography

Posturography is a computerised measure that is able to assess postural stability during a variety of tasks. It can distinguish the principle sensory, motor and biomechanical components contributing to postural stability, and analyse the client’s ability to effectively use these components singularly to maintain postural stability (Błaszczyk, 2008; Błaszczyk, Beck, & Sadowska, 2014; Di Girolamo et al., 1998; Kyrdalen, Moen, Roysland, & Helbostad, 2014; Raymakers, Samson, & Verhaar, 2005; Visser, Carpenter, van der Kooij, & Bloem, 2008). Computerised posturography offers two major categories of postural stability test: dynamic and static.

Dynamic posturography evaluates standing stability by inducing balance perturbations in the individual through moving the support surface (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014; Suttanon et al., 2012a; Visser et al., 2008). Previously, posturography platforms used to move in only one direction, but in more current versions, the platforms are able to perturb in multiple directions (Allum et al., 2002; Henry et al., 1998). Postural stability can be perturbed by a single or a combination of translations of support surface: horizontal, vertical, rotations, or a combination of these (Bloem, Visser, & Allum, 2003; Visser et al., 2008). Dynamic posturography has been used in a numbers of studies among older adults with Alzheimer’s disease (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014; Suttanon et al., 2012a).

Static posturography requires the person to maintain the stance position whilst standing on force plates (Allum et al., 2001; Henry et al., 1998). Static posturography records the amount of body sway that is influenced by gravity and small voluntary self-corrective
movements (Creath, Kiemel, Horak, & Jeka, 2002; Kuo, Speers, Peterka, & Horak, 1998). When using static posturography, the evaluation of postural control is based on the oscillations of the centre of foot pressure (COP) which are equivalent to the movement of spontaneous centre of mass (COM) motions on the level of the base of support (BOS) (Błaszczyk et al., 2014; Visser et al., 2008). This COP measurement can describe numerous characteristics and variability of postural sway either in the time- or in the frequency-series (Caron, 2003; Ferdjallah, Harris, & Wertsch, 1999; Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996; Schmit, Riley, Shear, & Shockley, 2004) (Visser et al., 2008). As such, it is able to evaluate multiple sensory organisations, namely information from somatosensory and vision that are important for the maintenance of postural stability (Horak, 1987, 1997; Shumway-Cook & Woollacott, 2007).

Manipulations are then made to increase the challenge of standing quiet, for example, reducing visual feedback (closed eyes), decreasing the size of the base of support (tandem stance), or reducing proprioceptive feedback (standing on a soft surface, e.g., foam) (Adkin, Bloem, & Allum, 2005; Allum et al., 2001; Bloem et al., 2003; Horak, 1987, 1997; Shumway-Cook & Woollacott, 2007; Visser et al., 2008; Isableu, Ohlmann, Crémieux, & Amblard, 2003; Lacour et al., 1997; Chong et al., 1999; de Andrade et al., 2014; Dickin & Rose, 2004; Elble & Leffler, 2000; Gago et al., 2014; Gras et al., 2015; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Suttanon et al., 2012a). For example, the Romberg ratio is the measurement of quiet standing with eyes closed divided by the measurement of quiet standing with eyes open (EC/EO) and is used widely as an indicator of the proprioceptive contribution to postural stability and the degree of visual dependency required to maintain static stance (Chong et al., 1999; de Andrade et al., 2014; Dickin & Rose, 2004; Elble & Leffler, 2000; Gago et al., 2014; Gras et al., 2015; Isableu et al., 2003; Lacour et al., 1997; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Suttanon et al., 2012a).

The advantage of static posturography is that it provides numerous theoretical understandings of the mechanism of the pathophysiology of an individual with postural
stability disorders. Other than that, the analysis of postural control, that is derived from the platforms, is influenced by the variations in the individual’s body mass or mass distribution (height and weight), in contrast to many clinical-based balance tests (Horak, 1987, 1997). The measurement of COP in static posturography has been used extensively and successfully demonstrates abnormalities of postural control in various types of populations (de Andrade et al., 2014; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Visser et al., 2008); for example, in older adults with neurological and cognitive problems, including Alzheimer’s disease (Suttanon et al., 2012a). Posturography also was found by other researchers, to be a feasible and reliable method to be used with older adults with Alzheimer’s disease (Suttanon, Hill, Dodd, & Said, 2011; de Andrade et al., 2014; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014).

2.4.2 Physiological Profile Approach

The Physiological Profile Approach (PPA) was invented by a research team from the Prince of Wales Medical Research Institute, Randwick, Sydney, NSW, Australia (Lord et al., 2003). There are two versions of the PPA - a comprehensive long version that requires 45 minutes to assess all domains; and a short version useful for screening when time is constrained. The short version requires 15 minutes to administer. The short version comprises a set of tests to measure A) postural stability (under four sensory conditions 1) EO; 2) and 3) EC on a firm surface or a foam surface; and 4) sensorimotor function assessment); B) hand reaction time; C) quadriceps muscle strength; D) proprioception; and E) visual acuity in older adults to evaluate falling risk.

A license to access a web-based computer software programme to calculate the risk of falling can be reached at https://www.neura.edu.au/fbrg. Login username and password are needed to access the web-based computer software programme. The web-based computer software programme generates four falling risk evaluation reports: 1) an overall falls risk score for each client, presented in a graph; 2) a test performances profile, which describes the physiological component affected; 3) the test performances in relation to age-matched norms presented in a table; and 4) a report that briefly describes the meaning of the results of assessing the falls risk and suggestions to
improve functional performances or suggestions to improve identified impairments (Lord et al., 2003).

A normative range of falls risk was developed based on data acquired from a random selection of 550 community-dwelling women in Australia (Lord, Clark, & Webster, 1991; Lord et al., 2003; Lord et al., 1994; Lord, Ward, Williams, & Anstey, 1994a). The PPA composite z-scores of 0, 1, 2 and 3 and above were used to indicate mild, moderate, high, and marked risk of falling, respectively (Lord et al., 2003).

There were a number of studies used to evaluate its validity with a total aggregate of more than 2,000 community-dwelling older adult participants and it was found to be a valid tool as a predictor of falls (Lord et al., 1991; Lord et al., 2003; Lord et al., 1994; Lord et al., 1994a). The PPA has been shown to be able to predict falls in older adults for long term period, with 75% accuracy; i.e., over a 12-month period and it was found to be reliable and sensitive during changes of performance associated with exercises (Lord et al., 1994a). The study also indicated standardised, canonical, correlation coefficients from community-dwelling participants, i.e., -0.16 for knee extension strength, -0.33 for visual contrast sensitivity, 0.47 for simple reaction time, 0.20 for proprioception, and 0.51 for sway on foam (Lord et al., 2003; Lord et al., 1994a; Taylor et al., 2012).

Although, the utility of the PPA in the older adult population is well known, its utility (i.e. feasibility, validity and reliability) for older adults with cognitive impairment is unclear. Table 2.2 illustrates a summary of studies that have utilised the PPA among older adults with cognitive impairment. Seven studies were retrieved with variation in the usage of the PPA. Three studies measure the risk factors for falling among older adults with cognitive impairment (Liu-Ambrose et al., 2008; Lorbach et al., 2007; Suttanon et al., 2012a). Lorbach et al. also evaluated test-retest reliability as part of their study (Lorbach et al., 2007). Two studies evaluated the magnitude of risk of falls after a 12 months’ post-intervention follow-up (Suttanon et al., 2013; Taylor et al., 2012). Taylor also evaluated sensitivity and specificity (Taylor et al., 2012). Another
two studies evaluated the change of risk after an intervention programme (Suttanon et al., 2013a; Wesson et al., 2013).

In a study by Liu-Ambrose et al. (2008), the researchers evaluated the correlation between falls risk, measured by the PPA, and executive functions, measured by the Trail Making Test, the Verbal Digit Span Backward Test and the Stroop Colour-Word Test, and the difference of fall risk factors using the PPA between a group of community-dwelling, older women, aged 65-75 with Mild Cognitive Impairment (MCI) and a control group of healthy peers (Liu-Ambrose et al., 2008). The composite PPA score was significantly associated with all three of these measurements of executive functions (p≤0.05) (measured by the Trail Making Test, the Verbal Digit Span Backward Test and the Stroop Colour-Word Test). There was also an overall significant difference between the two groups (with and without Mild Cognitive Impairment) for the physiological fall risk score (p = 0.04) (Liu-Ambrose et al., 2008). Similar positive findings were found in the studies by Suttanon et al. (2012) and Lorbach et al. (2007); that is, older adults with mild to moderate Alzheimer’s disease had a higher risk of falls as measured by the PPA (Lorbach et al., 2007; Suttanon et al., 2012a). Among these three studies (Liu-Ambrose et al., 2008; Lorbach et al., 2007; Suttanon et al., 2012a), only two studies evaluated the individual items of the PPA (Liu-Ambrose et al., 2008; Lorbach et al., 2007) and found significantly slower hand reaction time (Lorbach et al., 2007) and worse postural stability than with the control group (Liu-Ambrose et al., 2008; Lorbach et al., 2007). Results suggest that, older adults with cognitive impairment have more deficits in physiological function than control healthy peers.

Two studies evaluated the magnitude of change of fall risk in one year (Suttanon et al., 2013; Taylor et al., 2012). Suttanon et al. (2013) followed participants for 12 months to evaluate the magnitude of changes in risks of falling among older adults with mild to moderate Alzheimer’s disease (Suttanon et al., 2013a). The findings revealed that the number of falls was high in older adults with Alzheimer’s disease (p = 0.015) compared to control healthy peers but there was no change in the risk of falling as measured by the PPA (Suttanon et al., 2013). The prospective study by Taylor et al. (2012) found the same results in community-dwelling, cognitively impaired older adults. They found that
65% of 177 participants fell one or more times in the subsequent years (Taylor et al., 2012). Multiple falls (~43%) in Taylor et al.’s (2012) study was significantly associated with the fall risk score measured by the PPA, but there was no comparison of these data with control healthy peers (Taylor et al., 2012). Both studies (Suttanon et al., 2013; Taylor et al., 2012) suggest that, as time progresses, the rate of falls increases and the deterioration is marked in the physiological characteristics, as measured by PPA-vision; that is, in proprioception, muscle strength, hand reaction time, and postural stability.

The psychometric properties, of the PPA test among older adults with cognitive impairment, have been studied by two research groups (Lorbach et al., 2007; Taylor et al., 2012). In Taylor et al. (2012), the researcher evaluated the ability of the short-form PPA items to discriminate between non-multiple and multiple fallers. The area under the receiver operating curve (ROC) was 0.70 (95% CI 0.61, 0.78) for the five items in the PPA. This result indicates that the PPA can discriminate fallers and non-fallers among older adults with mixed types of dementia and cognitive impairment, even though not all components in PPA were associated with falls (Taylor et al., 2012).

The test re-test reliability of the PPA was evaluated in a study by Lorbach et al. (2007) among older adults with mild to moderate Alzheimer’s disease, with a mean (SD) age of 79 (6) years. The researchers found excellent intraclass coefficients (ICCs) ranging between 0.78 to 0.90, for contrast sensitivity and knee extension strength, fair-to-good ICCs (0.43–0.75) for hand reaction time, sway during standing on foam surface (EC) and the overall falls risk score (Lorbach et al., 2007). However, ICCs were poor (0.18–0.39) for proprioception, sway during standing on floor (in both condition with EO and EC) and sway during standing on foam surface (EO) (Lorbach et al., 2007). Although some participants in this study had difficulty completing tests involving contrast visual acuity and postural sway on foam with EO and EC, the PPA was found to be feasible to conduct in older adults with Alzheimer’s disease, with the majority of the participants completing the test (Lorbach et al., 2007).

Two feasibility randomised controlled trials (RCTs) used the PPA to evaluate the changes of fall risk after following an individually tailored, home exercise programme.
Both studies prescribed a combination of strengthening and balance exercises. After a 6 months (Suttanon et al., 2013a) and 1 year of intervention (Wesson et al., 2013) respectively, the PPA falls risk score did not show a significant improvement (p > 0.05) (Suttanon et al., 2013a; Wesson et al., 2013). Whilst these results may reflect reduced intervention effectiveness, they might also suggest that a more comprehensive outcome measure of fall risk is required, in addition to the physiological risk factors tested in the PPA. Other measurements could be added, such as including the type and numbers of medications consumed and the ability to perform more complex functional tasks, such as turning (Suttanon et al., 2013). Medications were found to be an important contributor to the increased incidence rate of falls (Berdot et al., 2009; Hartikainen et al., 2007; Tinetti, Williams, & Mayewski, 1986). Whereas, during turning, older adults who are at high risk of falling will take additional steps (Dite & Temple, 2002), decrease velocity (Courtine & Schieppati, 2003; Orendurff et al., 2006; Turcato, Godi, Giordano, Schieppati, & Nardone, 2015) and take longer (Wall, Bell, Campbell, & Davis, 2000), all strategies designed to increase stability. Thus turning is likely the activity that increases the risk of falling in older adults (Tinetti et al., 1986). In the study by Wesson et al. (2013), participants were heterogeneous in terms of physical activity and cognitive function, and this heterogeneity may have introduced variability in the performance of each component in the PPA. Another factor not tested in these studies was fear of falling, which has been found to impact physical performance in older adults (Maki, Holliday, & Topper, 1991).

Few studies to date have utilised the PPA in research involving older adults with cognitive impairment. Whilst the psychometric properties of the PPA have been evaluated among older adults with cognitive impairment, they have not specifically been tested in older adults with Alzheimer’s disease. This is where more work is required.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
<th>Participants</th>
<th>Control</th>
<th>Description of the study</th>
<th>Results</th>
<th>Pedro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liu-Ambrose et al. (2008)</td>
<td>CS</td>
<td>n = 86</td>
<td>n = 72</td>
<td>Fall risks score was compared between older adults with MCI and control healthy peers.</td>
<td>The index PPA score was significantly associated with all 3 executive functions (p &lt; 0.05)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = NA</td>
<td>F = NA</td>
<td>PPA index score (p &lt; 0.01) and postural sway (p = 0.03) higher in MCI compared to control healthy peers.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Age = 70 (3)</td>
<td>Age = 70 (3)</td>
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<tr>
<td></td>
<td></td>
<td>Population = MCI</td>
<td>Population = control healthy peers</td>
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<td></td>
<td></td>
<td>MMSE = 29 (1)</td>
<td>MMSE = 28 (1)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Setting = com-dwell</td>
<td>Setting = com-dwell</td>
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<tr>
<td>Suttanon et al. (2012a)</td>
<td>CS</td>
<td>N = 25</td>
<td>n = 25</td>
<td>Comparison of postural stability among older adults with mild-moderate AD and control healthy peers.</td>
<td>Older adults with mild-moderate AD have higher risk of falls (p = 0.007) compared control healthy peers.</td>
<td>-</td>
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<td></td>
<td></td>
<td>F = 16</td>
<td>F = 16</td>
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<tr>
<td></td>
<td></td>
<td>Age = 80 (range 78-83)</td>
<td>Age = 81 (range 78-84)</td>
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<tr>
<td></td>
<td></td>
<td>Population = Mild-moderate AD</td>
<td>Population = control healthy peers</td>
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<td></td>
<td></td>
<td>MMSE = 21 (19-23)</td>
<td>MMSE = 29 (28-30)</td>
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<td></td>
<td>Setting = com-dwell</td>
<td>Setting = com-dwell</td>
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<tr>
<td>Lorbach et al. (2007)</td>
<td>Feas., psycho metric.</td>
<td>n = 21</td>
<td>n = 21</td>
<td>Comparison of the postural stability among older adults with mild-moderate AD and control healthy peers.</td>
<td>AD have higher overall falls risk (p &lt; 0.02), slower RT (p &lt; 0.01), more postural sway (p &lt; 0.005) than control healthy peers.</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>F = 11</td>
<td>F = 11</td>
<td></td>
<td>Test re-test reliability, high ICC (0.78-0.90); low contrast sensitivity, quadriceps strength and postural sway; fair ICC (0.43-0.75); hand reaction time, sway on foam eyes closed and fall risk</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Age = 79 (6) (range 63-91)</td>
<td>Age = 79 (6) (range 63-91)</td>
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<tr>
<td></td>
<td></td>
<td>Population = Mild-moderate AD</td>
<td>Population = control healthy peers</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>MMSE = 11-26</td>
<td>MMSE = -</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Setting = outpatient neurology clinic</td>
<td>Setting=retirement village residents</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Study</td>
<td>Design</td>
<td>n</td>
<td>F</td>
<td>Age</td>
<td>Population</td>
<td>MMSE</td>
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</tr>
<tr>
<td>Suttanon et al. (2013)</td>
<td>LS</td>
<td>15</td>
<td>7</td>
<td>81 (5)</td>
<td>mild to moderate AD</td>
<td>22 (5)</td>
</tr>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>RCT</td>
<td>19</td>
<td>13</td>
<td>83 (5)</td>
<td>AD</td>
<td>21 (5)</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RCT</td>
<td>11</td>
<td>5</td>
<td>79 (4)</td>
<td>dementia</td>
<td>25 (3)</td>
</tr>
</tbody>
</table>

**Notes.** AD, Alzheimer’s disease; AUC, area under curve; CS, cross sectional; com-dwell, community-dwelling; eyes open, EO; EC, EC closed Feas., feasibility; LS, longitudinal study; MCI, Mild Cognitive Impairment; MMSE, Mini Mental State Examination; n, subpopulation; OEP, Otago Exercise Programme; PPA, Physiological Profile Approach; Prosp., prospective; RCT, randomised control trial; RT, reaction time. All values are mean (standard deviation) or as otherwise indicated.
2.4.3 Timed Up and Go test

The Timed Up and Go test (TUG) (Podsiadlo & Richardson 1991) is used to measure functional postural stability. The test includes basic everyday movements such as standing up, walking, turning and sitting. This test measures the time (duration in seconds) for the participant to stand up from a standard chair without an arm rest, walk 3 metres at their usual pace, turn, walk back and sit down again in the chair (Podsiadlo & Richardson, 1991). It was originally developed to measure balance of older adults (Mathias, Nayak, & Isaacs, 1986). The scoring is based on the perception of evaluator about the performance of older adults as to whether or not they have a risk of falling during the test (Mathias et al., 1986). The score is an ordinal scale of 1 to 5 (Mathias et al., 1986). Podsiadlo and Richardson (1991) modified the original test which aimed to test basic mobility skills for frail, community-dwelling, older adults by timing the task completion in seconds (Podsiadlo & Richardson, 1991). The less time taken to complete indicates good mobility. The test has been recommended by the American Geriatrics Society / British Geriatrics Society (Kenny et al., 2011) and National Institute of Clinical Evidence (NICE) (Barry et al., 2014) as a screening outcome measure for detecting older people at increased risk of having falls.

The TUG test was reported to be reliable and valid to be used on older people who are medically stable with good cognitive functions (Freter & Frucher, 2000; Newton, 1997; Podsiadlo & Richardson, 1991; Shumway-Cook, Brauer, & Woollacott, 2000). In the healthy, older adult population, a person aged 60 to 69 years, aged 70-79, and 80 to 99 years of age should finish the test in 9, 10.2 and 12.7 seconds, respectively (Moncada, 2011). In a study by Shumway-Cook (2000), a cut off point of 13.5 seconds was found to significantly discriminate between fallers and non-fallers, with 87% of subjects correctly classified. Less time to complete the task was reflective of good functional postural stability.

A recent study (Ho & Loy, 2015) supported the TUG test as one of the best tools to measure a performance-based functional stability because of its advantages; i.e., within the context of good psychometric properties, and its correlation with both physical and health measures. However, to date, these data have only been presented as a conference...
abstract; thus, it is unclear whether the suggestion was for both older adults with and without dementia, or for just anyone within this age population (Ho & Loy, 2015). Although, the utility of the TUG test in the older adult population is well known, its utility, feasibility, validity and reliability for older adults with cognitive impairment are unclear.

Table 2.3 illustrates four studies that have utilised the TUG test to evaluate functional postural stability in older adults with Alzheimer’s disease, and compare the results with those of the control group of healthy peers (Gras et al., 2015; Pettersson et al., 2002; Pettersson et al., 2005; Suttanon et al., 2012a). Participant mean (SD) age was 74 (7) (range 58-82) years; they were recruited from clinics and the community; and had mild to moderate cognitive impairment (MMSE mean (SD) 23 (3), range 17-30). Sample sizes ranged from small (n = 13) (Gras et al., 2015) to moderate (n = 50) (Suttanon et al., 2012a). All studies found consistently significant results which suggests that older adults with mild to moderate Alzheimer’s disease have reduce performances in the TUG test compared to control healthy peers.
Table 2.3 Characteristics of studies reviewed in this chapter (postural stability studies utilised Timed Up and Go test)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
<th>Participants</th>
<th>Control</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gras et al. (2015)</td>
<td>CS</td>
<td>n = 13</td>
<td>n = 13</td>
<td>TUG AD = 8.1 (2.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 3</td>
<td>F = 3</td>
<td>TUG control = 5.2 (0.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, year = 73 (5)</td>
<td>Age, year = 72.6 (4.6)</td>
<td>Significant difference (p &lt; 0.00)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMSE = 25 (3)</td>
<td>MMSE = 29.0 (1.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = University of Kansas AD Center</td>
<td>Setting = Personal contact of researchers</td>
<td></td>
</tr>
<tr>
<td>Pettersson et al. (2005)</td>
<td>CS</td>
<td>n = 21</td>
<td>n = 31</td>
<td>TUG AD = 9.9 (2.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 10</td>
<td>F = 13</td>
<td>TUG control = 7.8 (1.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, year = 68 (10)</td>
<td>Age, year = 57 (9.2)</td>
<td>Significant difference (p ≤ 0.05)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMSE = 24 (range 17 - 30)</td>
<td>MMSE = 29 (range 27-30)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = Referral from clinics and specialist</td>
<td>Setting = Unable to determine</td>
<td></td>
</tr>
<tr>
<td>Pettersson et al. (2002)</td>
<td>CS</td>
<td>n = 17</td>
<td>n = 18</td>
<td>TUG AD = 11 (range 8 -23)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 8</td>
<td>F = 9</td>
<td>TUG control = 9 (7-14)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, year = 74 (range 67-82)</td>
<td>Age, year = 74 (range 64-84)</td>
<td>Significant difference (p &lt; 0.00)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMSE = 25 (range 21-29)</td>
<td>MMSE = 29.5 (range 27-30)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = Memory clinics at Huddinge University Hospital</td>
<td>Setting.= relative of the participants with AD/ pre-existing register of healthy control</td>
<td></td>
</tr>
<tr>
<td>Suttanon et al. (2012a)</td>
<td>CS</td>
<td>n = 25</td>
<td>n = 25</td>
<td>TUG AD = 15.04 (95% CI 13.71 -16.37)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 16</td>
<td>F = 16</td>
<td>TUG control = 11.89 (95% CI 10.93 -12.85)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, year = 81 (95% CI 78.4 - 83.5)</td>
<td>Age, year = 81 (95% CI 78.0 - 82.7)</td>
<td>Significant difference (p &lt; 0.00)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMSE = 21 (95% CI 19.2 - 23)</td>
<td>MMSE = 29.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = Memory clinic and community</td>
<td>Setting = Community and existing volunteer database from a research institute</td>
<td></td>
</tr>
</tbody>
</table>

Notes. AD, Alzheimer’s disease; CI, confidence interval; CS, cross sectional; F, female; MMSE, Mini Mental State Examination; n, subpopulation; SD, standard deviation. All values are mean (standard deviation) or as otherwise indicated.
Table 2.4 illustrates a summary of 10 studies which evaluated the psychometric properties of the TUG test and which included older adults with cognitive impairment (n = 2) (Fischer et al., 2014; Whitney et al., 2005), dementia (n = 5) (Blankevoort et al., 2013; Nordin et al., 2006; Rockwood et al., 2000; Thomas & Hageman, 2002; van Iersel et al., 2008), and Alzheimer’s disease (n = 3) (Ries et al., 2009; Suttanon et al., 2012a; Tappen et al., 1997). The psychometric property that these studies evaluated was the reliability of the TUG test to predict falls in older adults with cognitive impairment.

The relative reliability of the Timed Up and Go in five studies were consistently of ‘excellent reliability’ with ICC values ranging between .90-.95 (Blankevoort et al., 2013), ICC = 0.973 (Ries et al., 2009), ICC = 0.97 (van Iersel et al., 2008), intra-rater ICC = 9.2, inter-rater ICC = 9.1 (Nordin et al., 2006), ICC = 0.71-0.96 (Tappen et al., 1997), and two studies with ‘very reliable’ ICC = 0.87 (Thomas & Hageman, 2002) and ICC = 0.75 (Suttanon et al., 2011) respectively. Only one study found ‘poor reliability’ with an ICC = 0.56 (Rockwood et al., 2000). The disparities of the findings of very poor reliability could be explained by the 112-day average time lapse between test and retest (Rockwood et al., 2000), and the small sample size (Thomas & Hageman, 2002).

In a study by Tappen et al. (1997), the examiner was allowed to use a combination of verbal or physical cueing. Participants with more severe cognitive impairment were provided some physical assistance to stand up from the chair (Tappen et al., 1997), and this may have influenced their finding of high reliability. All eight studies support the TUG test as a reliable outcome measure to evaluate the changes in response to intervention, even in older adults with severe cognitive impairment.

The variability of the performance of the TUG test can be influenced by many factors. These factors include cognitive impairment (Ayan, Cancela, Gutierrez, & Prieto, 2013; Ries et al., 2009), the cue used during the test (Nordin et al., 2006; van Iersel et al., 2008), variability in the walking speed or step length (Alexander, 1996; Ries et al., 2009; van Iersel, Hoefsloot, Munneke, Bloem, & Rikkert, 2004), learning effect or confidence level (Nordin et al., 2006), fatigue and/or even the assessor who conducted the test. A study by Phillips et al. (1993) indicated that variability in cognitive function
has a negative influence on the reliability of the test performance (Phillips, Chu, Morris, & Hawes, 1993). Moreover, older adults with weak quadriceps muscle strength were more likely to be cued during performing of the test (Nordin et al., 2006).

Table 2.4 Characteristics of studies reviewed in this chapter (psychometric studies of the Timed Up and Go test)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
<th>Participants</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ries et al. (2009)</td>
<td>Prospective psychometric study</td>
<td>n = 51, F = 34, Age, year = 81 (9), Population = AD, MMSE = 13 (8), Setting = NA</td>
<td>Test-retest reliability ICC = 0.973</td>
</tr>
<tr>
<td>Suttanon et al. (2011)</td>
<td>Prospective psychometric study</td>
<td>n = 14, F = 7, Age, year = 80 (6), Population = AD, MMSE = 21 (5), Setting = Community</td>
<td>Test-retest reliability TUG[B] ICC 0.8, TUG[M] ICC 0.7, TUG[C] ICC 0.5</td>
</tr>
<tr>
<td>Tappen et al. (1997)</td>
<td>Prospective psychometric study</td>
<td>n = 33, F = 65%, Age, year = 84 (range 79-92), Population = AD, MMSE = 0-24, Setting = LTC</td>
<td>Intra-rater ICC 0.58-0.70, Inter-rater ICC 0.71-0.96</td>
</tr>
<tr>
<td>Blankevoort et al. (2013)</td>
<td>Prospective psychometric study</td>
<td>n = 58, F = 41, Age, year = 82, Population = dementia, MMSE = 19, Setting = nursing home, day care centre</td>
<td>Test-retest reliability ICC 0.90-0.95</td>
</tr>
<tr>
<td>Marianne B. van Iersel et al. (2008)</td>
<td>Prospective psychometric study</td>
<td>n = 85, F = 46, Age, year = 76 (7), Population = dementia (n = 38), MMSE = 22 (6), Setting = inpatient</td>
<td>Test-retest reliability ICC 0.97, Cut off 13.5</td>
</tr>
</tbody>
</table>
Table 2.5 illustrates the summary of the 10 studies that used the TUG test to measure the change of functional postural stability following interventions with older adults with Alzheimer’s disease. This is a narrative literature review. The quality of RCT, systematic review and meta-analysis were checked in Pedro, a free Physiotherapy evidence database (https://www.pedro.org.au/). There were three RCT studies with a PEDro quality of: 8/10 (Rolland et al., 2007) and 6/10 (Suttanon et al., 2013a). The third study was of unknown quality as it has only been published to date as an abstract (Claire et al., 2016), two longitudinal studies (Hernandez et al., 2010; Pedroso et al., 2012), four pre-post experimental studies (Ahn & Kim, 2015; de Andrade et al., 2013; Ries et al., 2010; Ries et al., 2015), one case study (Abreu & Hartley, 2013). Two of these 10 studies were available as abstracts (Claire et al., 2016; Hernandez et al., 2010) and one was published in Portuguese (Hernandez et al., 2010). The study sample sizes varied from a single case study (Abreu & Hartley, 2013) to 134 (Rolland et al., 2007). Participants’ cognitive impairment ranged from mild to severe (Mean (SD) =22 (4),

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>n</th>
<th>F</th>
<th>Age, year</th>
<th>Population</th>
<th>MMSE</th>
<th>Setting</th>
<th>Test-retest reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas and Hageman (2002)</td>
<td>Prospective psychometric study</td>
<td>n = 12</td>
<td></td>
<td>81 (6)</td>
<td>Dementia (n=41) and multi diagnosis</td>
<td>19 (6)</td>
<td>Residential care</td>
<td>ICC 0.87</td>
</tr>
<tr>
<td>Rockwood et al. (2000)</td>
<td>Retro. Psychometric study</td>
<td>n = 2335</td>
<td></td>
<td>78 (range 69-104)</td>
<td>Cognitively impaired (n = 1461)</td>
<td>NA</td>
<td>LTC + community</td>
<td>ICC 0.56</td>
</tr>
</tbody>
</table>

Notes. AD, Alzheimer’s disease; B, basic; C, cognitive; ICC, Intraclass Correlation Coefficient; F, female; LTC, long term care; M, manual; n, sample size; NA, not available; s, second.
All values are mean (standard deviation) or as otherwise indicated.
range = 2-25). Many studies demonstrated improved performance in the TUG through descriptive statistical analysis (Abreu & Hartley, 2013; Claire et al., 2016; de Andrade et al., 2013; Hernandez et al., 2010) following an exercise programme. Four studies, inclusive of the moderate quality studies, did not show any change in performance in this test following exercise (Pedroso et al., 2012; Ries et al., 2015; Rolland et al., 2007; Suttanon et al., 2013a). These studies suggest, despite a lack in the sensitivity of the TUG test to evaluate change in performance, that the TUG test provides valuable information when descriptively statistically analysed.

The TUG test was found to be feasible to be conducted among older adults with cognitive impairment with and without Alzheimer’s disease. For those with functional impairment, the reviewed literature found a modification to the original protocol of the TUG test would not change the reliability of the measurement. From the reviewed literature, the most common assistance given was verbal and physical cueing especially when the participant had to sit back in the chair to complete the test. Even though the reviewed literature found an inconsistency in results post exercise intervention, the TUG test still provides valuable information in relation to functional postural stability of older adults with cognitive impairment.
### Table 2.5 Characteristics of studies reviewed in this chapter (Intervention studies utilised Timed Up and Go test)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
<th>Participants</th>
<th>Intervention</th>
<th>Results</th>
<th>Pedro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abreu and Hartley (2013)</td>
<td>Case study</td>
<td>n = 1</td>
<td>To evaluate the effectiveness of salsa dancing.</td>
<td>TUG decreased 63s</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 1</td>
<td>Duration = 3months</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, year = 83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population = AD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SLUMS = 7/30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ahn and Kim (2015)</td>
<td>Pre-post exp.</td>
<td>n = 23</td>
<td>To evaluate the effectiveness of UL and LL exercises – elastic band resistance exer. (warm up, resistance exercise, cool down)</td>
<td>No significant difference p &gt; 0.05 TUG</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = NA</td>
<td>Duration = 5months</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, year = 74 (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population = AD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMSE = 10-19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Andrade et al. (2013)</td>
<td>Pre-post exp.</td>
<td>n = 30</td>
<td>To evaluate the effectiveness of multimodal exercise (warm-up, aerobic, dual task, strengthening exer.)</td>
<td>TUG, Wilks k = 0.324, F(6,19) = 6.621, P = .001, partial n² = 0.676</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 24</td>
<td>Duration = weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population = AD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CDR = Mild to moderate CI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = Kinesiotherapy programme for seniors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claire et al. (2016)</td>
<td>RCT (abstract)</td>
<td>n = 40</td>
<td>To evaluate the effectiveness of light physical activity or walking</td>
<td>A significant decrease in the completion time of the TUG (T1: 23.1 (8.1) s; T2: 19.5 (6.1) s)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, year = 80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population = AD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMSE = NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration = 8weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting = NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study (Year)</td>
<td>Design</td>
<td>Sample Size</td>
<td>Gender</td>
<td>Age (Mean ± SD)</td>
<td>Population</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>-------------</td>
<td>--------</td>
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<td>------------</td>
</tr>
<tr>
<td>Hernandez et al. (2010)</td>
<td>LS (abstract, full paper in Portuguese)</td>
<td>n = 16</td>
<td>F = NA</td>
<td>Age, year = 79 (7)</td>
<td>Population = AD</td>
</tr>
<tr>
<td>Pedroso et al. (2012)</td>
<td>LS</td>
<td>n = 21</td>
<td>F = NA</td>
<td>Age, year = 78 (7)</td>
<td>Population = AD</td>
</tr>
<tr>
<td>Ries et al. (2010)</td>
<td>pre-post exp. study</td>
<td>n = 5</td>
<td>F = 1</td>
<td>Age, year = range 81-93</td>
<td>Population = AD</td>
</tr>
<tr>
<td>Ries et al. (2015)</td>
<td>pre-post exp. study</td>
<td>n = 22</td>
<td>F = 14</td>
<td>Age, year = 79 (11)</td>
<td>Population = AD</td>
</tr>
<tr>
<td>Rolland et al. (2007)</td>
<td>RCT</td>
<td>n = 134</td>
<td>F = 101</td>
<td>Age, year = 83 (7)</td>
<td>To evaluate the effectiveness of walking, LL resistance and balance exercises.</td>
</tr>
</tbody>
</table>
Population = AD  
MMSE = 9 (7)  
Setting = Nursing home

Duration = 12 months

Suttanon et al. (2013a)  FS, pilot RCT  n = 40  
F = 25  
Age, year = 82 (6)  
Population = AD  
MMSE = 21 (5)  
Setting = community

To evaluate the feasibility of individual tailored home exercise programme.  
Duration = 6 months  
No significant difference p > 0.05 TUG.

Notes. AD, Alzheimer’s disease; exer., exercise; F, female; FS, feasibility; LL, lower limb; MDC, Minimal Detectable Change; MMSE, Mini Mental State Examination; n, sample size; NA, not available; n, subpopulation; TUG, Timed Up and Go; RCT, Randomised Controlled Trial.

All values are mean (standard deviation) or as otherwise indicated.
2.4.4 Rationale and study position of evaluating risk of falling

Postural impairment and falls risk are of serious concern for older adults with Alzheimer’s disease and interventions to address these issues are of high priority. First, it is necessary, however, to be able to reliably measure postural stability and falls risk in older adults with Alzheimer’s disease. Many studies have focused on such measurements in older adults per se but not for older adults with Alzheimer’s disease. Measurement of postural stability and falls risk requires a combination of history taking and physical examination, but both approaches have limitations when used with older adults with Alzheimer’s disease. Asking individuals about prior falls may be unreliable because of poor memory (Cummings, Nevitt, & Kidd, 1988) and thus the researcher relies on caregivers to remember or provide detail. Clinically used postural stability tests also have limitations; these are suboptimal due to variable execution and subjective scoring systems (Jacobs, Horak, Tran, & Nutt, 2006; Munhoz et al., 2004).

As such, a clinical outcome measure of postural stability only provides a basic and subjective estimate and understanding of potential abnormalities in the components that might be affecting postural stability. Such a clinical outcome measure also may underestimate the abnormal functioning of selective components of the postural stability repertoire. The latter is important to ensure treatment is targeted appropriately.

There is a need for the clinicians to document the outcome of interventions using a reliable tool which, objectively and quantitatively, analyses postural stability. This is needed not only in clinical practice, but also in research, to evaluate the success of interventions with patients. Even though there is no one outcome measure that can assess all pertinent systems of postural stability, Horak (2006) recommends that, with respect to cognitively challenged populations, the outcome measure used should be quick to execute and instructions easy to follow (Horak, 2006). For example, laboratory measures of postural stability widely used in clinical and research settings, such as posturography, provide more reliable, comprehensive and objective measures. It is not however readily available in the community setting as it is not practical or easily transportable, and can be timing consuming to execute.
The PPA and TUG test are clinically applied tests that potentially meet the above mentioned requirements of being ‘quick to execute’ and ‘easy to follow instructions’, but there is limited evidence of their psychometric properties for use to evaluate fall risk and postural stability in older adults with mild to moderate Alzheimer disease. Therefore in this thesis, I further tested both these outcome measures and compared them to posturography measures (as a “gold standard” measure) in older adults with Alzheimer’s disease.

2.5 Strategies to reduce the risk of falls

Various approaches can be considered in designing interventions to improve postural stability for older adults with Alzheimer’s disease. This thesis adopted a complex intervention approach and used quantitative and qualitative background literature to develop background knowledge and subsequently a methodological rationale for the study design in Chapter 3 and, as discussed in this section, section 2.6, and three studies in Chapters 4, 5 and 6.

2.5.1 Exercise recommendations for older adults with Alzheimer’s disease

Extensive work has been done to set up exercise guidelines for older adults to promote health and prevent disease. For example, the American College of Sport Medicine together with the American Heart Association published some general guidelines that focused on adults aged 65 years and above who have body structure, and function and ability limitations (Nelson et al., 2007). Subsequently, more specific clinical practice guidelines for falls prevention were published by the American Geriatrics Society and British Geriatrics Society for older adults living in the community (Avin et al., 2015; Kenny et al., 2011). Exercise programmes have the most robust evidence for reducing the rate of falls in older adults, typically via those that are multiple-component or multi-factorial (Gillespie et al., 2012; Kenny et al., 2011; Li et al., 2016; Nelson et al., 2007; Sherrington et al., 2011).

Based on the recommendation from the American Geriatrics Society/ British Geriatrics Society (Kenny et al., 2011), ACSM (Haskell et al., 2007; Nelson et al., 2007), expert opinion (Avin et al., 2015) and systematic reviews in the area of falls prevention
(Gillespie et al., 2012; Sherrington et al., 2011), there are five aspects that should be considered before prescribing an exercise intervention to an older adult. These are: (1) level of fitness; (2) general health; (3) level of previous physical activity participation; (4) risk of falls; and (5) other safety issues. The exercise intervention should be planned to begin with small amounts of activity that are slowly increased to enable sustained long term engagement.

2.5.2 Interventions to improve postural stability and for fall prevention in older adults with Alzheimer’s disease

Table 2.6 summarises the 15 studies I found that investigated exercise to improve postural stability and as part of falls prevention programmes for older adults with Alzheimer’s disease (Ahn & Kim, 2015; de Andrade et al., 2013; Hernandez et al., 2010; Mirolsky-Scala & Kraemer, 2009; Öhman et al., 2016; Suttanon et al., 2013a). Among these studies, seven were RCTs (Claire et al., 2016; Kim et al., 2016; Öhman et al., 2016; Padala et al., 2017; Rolland et al., 2007; Santana-Sosa, Barriopedro, López-Mojares, Pérez, & Lucia, 2008; Suttanon et al., 2013a), four studies were pre-post experimental (Ahn & Kim, 2015; de Andrade et al., 2013; Ries et al., 2010; Ries et al., 2015), two were longitudinal studies (Hernandez et al. 2010; Pedroso et al., 2012), and two were single case studies (Abreu & Hartley, 2013; Mirolsky-Scala & Kraemer, 2009). The details of four of these studies (RCT = 3 studies, pre-post experimental = 1 study) were extracted through abstracts as the full text articles are not yet available (Claire et al., 2016; Öhman et al., 2016; Padala et al., 2017) and one article was written in Portuguese (Hernandez et al., 2010). Across all studies except one, participants were older adults aged between 73-93 years. In one study, the age of participants was unavailable in the abstract (Öhman et al., 2016). Participants varied in terms of the level of cognitive impairment; five studies included older adults with mild to moderate (MMSE score between 10-26) cognitive impairment (Ahn & Kim, 2015; de Andrade et al., 2013; Kim et al., 2016; Pedroso et al., 2012; Ries et al., 2010; Ries et al., 2015; Santana-Sosa et al., 2008; Suttanon et al., 2013a); three studies included adults with severe cognitive impairment (Saint Louis University Mental Status (SLUM) = 7/30) (Abreu & Hartley, 2013) (MMSE score = 8.8 (6.6) (Rolland et al., 2007), Clinical Dementia Rating = 3 (Mirolsky-Scala & Kraemer, 2009); and three studies did not present that information (Claire et al., 2016; Öhman et al., 2016; Padala et al., 2017).
The sample size varied from a single case study (Mirolsky-Scala & Kraemer, 2009) to 194 people (Öhman et al., 2016). Only seven studies reported on sex (de Andrade et al., 2013; Kim et al., 2016; Mirolsky-Scala & Kraemer, 2009; Ries et al., 2010; Rolland et al., 2007; Santana-Sosa et al., 2008; Suttanon et al., 2013a). The highest proportion of females (101 females of 134 participants) was found in the study by Rolland et al. (2007) (Rolland et al., 2007). The settings of the study were long term care residential care (Kim et al., 2016; Mirolsky-Scala & Kraemer, 2009; Rolland et al., 2007; Santana-Sosa et al., 2008), adults living in the community (Padala et al., 2017; Suttanon et al., 2013a) and through specific programmes for seniors (de Andrade et al., 2013; Ries et al., 2010). Some studies did not report setting information clearly or the information was not available in the abstract (Ahn & Kim, 2015; Claire et al., 2016; Hernandez et al., 2010; Öhman et al., 2016; Pedroso et al., 2012).

The quality for the RCT studies was checked through the PEDro database (https://www.pedro.org.au/), a web check for the quality of RCTs, systematic reviews and meta-analysis. The quality of the RCT studies ranged from 4 to 8 from the total possible score of 10. Only one study was considered of high quality (8/10) (Rolland et al., 2007), three were of moderate quality (5-6/10) (Kim et al., 2016; Öhman et al., 2016; Padala et al., 2017; Suttanon et al., 2013a) and one of low quality (4/10) (Santana-Sosa et al., 2008). The low to moderate quality of evidence was predominantly due to limited concealment or no concealment of allocation (Öhman et al., 2016; Santana-Sosa et al., 2008), no blind assessor (Kim et al., 2016; Öhman et al., 2016; Padala et al., 2017; Suttanon et al., 2013a; Santana-Sosa et al., 2008), limited baseline comparison (Suttanon et al., 2013a), no adequate follow-up (Padala et al., 2017; Santana-Sosa et al., 2008; Suttanon et al., 2013a) and no intention to treat data analysis (Öhman et al., 2016; Santana-Sosa et al., 2008). Blinding the therapist and participants is not possible in an exercise-based intervention. Another RCT study was not rated due to the full text not being available (Claire et al., 2016). The remaining pre-post experimental studies fall under the category of low level of evidence, thus their quality was not specifically rated.
All studies involved an intervention and a control group except for five studies which had a single intervention group (Abreu & Hartley, 2013; Ahn & Kim, 2015; Mirolsky-Scala & Kraemer, 2009; Ries et al., 2010; Ries et al., 2015). Nine studies used a multi-exercises type intervention programme and included a combination of strengthening exercises (Ahn & Kim, 2015; de Andrade et al., 2013; Rolland et al., 2007; Santana-Sosa et al., 2008; Suttanon et al., 2013a), flexibility exercises (Ahn & Kim, 2015; de Andrade et al., 2013; Kim et al., 2016; Pedroso et al., 2012; Ries et al., 2015; Santana-Sosa et al., 2008), walking (Claire et al., 2016; Padala et al., 2017; Rolland et al., 2007; Santana-Sosa et al., 2008; Suttanon et al., 2013a), aerobic fitness (de Andrade et al., 2013; Kim et al., 2016; Pedroso et al., 2012; Ries et al., 2015) and exercises that targeted postural stability, for instance, single leg stance (Mirolsky-Scala & Kraemer, 2009; Padala et al., 2017; Pedroso et al., 2012; Ries et al., 2010; Ries et al., 2015; Rolland et al., 2007; Santana-Sosa et al., 2008; Suttanon et al., 2013a). Only three studies used one specific type of exercise in their programme (Abreu & Hartley, 2013; Ahn & Kim, 2015; Padala et al., 2017). Ahn et al. (2015) used resistance exercise, Abreu and Hartley (2013) used dance, and Padala et al. (2017) used Wii-Fit as an intervention programme. Only three studies included cognitive tasks (de Andrade et al., 2013; Kim et al., 2016; Pedroso et al., 2012) in their study protocol.

A study by de Andrade et al. (2013) followed the recommendations of exercise by American College of Sport Medicine (2009) (de Andrade et al., 2013). This study designed the protocol based on the underlying theory that falls are related to frontal cognitive function and affect the executive functions which are required for postural control during execution of movements such as walking. Thus the intervention protocol was a combination of aerobic, muscle strengthening, flexibility and balance exercises recommended by American College of Sport Medicine. In additional to that, cognitive elements with special emphasis on executive function, attention and language, were included. The cognitive elements were added during the execution of the physical task; for example, during walking the participants were asked to count backward. A similar protocol was utilised by the study by Pedroso et al. (2012) (Pedroso et al., 2012). Rolland et al. (2007) were utilising an exercise prescription from a compilation of previous studies (Guralnik et al., 2000; Jirovec, 1991; Lazowski et al., 1999; Teri et al., 2007).
Whereas, in a study by Santana and colleagues, the justification of their exercise programme was an emphasis on flexibility, neuromuscular coordination and strength important for daily living (Santana-Sosa et al., 2008). For example, they tested whether increasing range of motion in the ankle joint could improve the kinetic and ankle joint strategy while doing activities of daily living (Cao, Maeda, Shima, Kurata, & Nishizono, 2007).

The duration of these intervention exercises was between 30 and 75 minutes. The frequency of the exercise ranged from 2 to 5 times per week, with the length of the intervention period between one (Mirolsky-Scala & Kraemer, 2009) to 12 months (Öhman et al., 2016). All studies delivered the intervention in a group setting except three which were individualised home / institutional exercise programmes (Abreu & Hartley, 2013; Santana-Sosa et al., 2008; Suttanon et al., 2013a). The intensity of the exercise programme was only reported by two studies (de Andrade et al., 2013; Kim et al., 2016). Kim et al. (2016) measured the intensity of activity by calculating the low intensity of 40-60% of maximum heart rate corresponding to a Borg score of between 11-13. Whereas, in the low quality study by de Andrade et al. (2013), participants maintained moderate activity prescribed as 65-75% of maximum heart rate. The variation in intensity in these two studies could be due to the level of cognitive impairment. Participants in the Kim et al. (2016) intervention were reported as having moderate cognitive impairment whereas in de Andrade and colleagues (2013) included participants who had mild to moderate cognitive impairment. Based on the ACSM, the intensity of the intervention should be appropriate based on the fitness level of the participants (Nelson et al., 2007).

The justification for these parameters varied for each study. For example, Rolland et al. (2007) argued that the more intensive the exercise programme, the more effective it would be (Rolland et al., 2007). They prescribed high intensity to older adults with severe cognitive impairment in long term care; however, they did not mention the practicality of the intervention in terms of the level of supervision needed to support

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2 Borg score is a perceived exertion sufficient to measure dyspnoea (breathlessness) (Wilson & Jones, 1989).
each participant. If each participant needed one supervisor, the intervention may not be practically feasible due to cost. In comparison, in the study by Suttanon et al. (2013), the intervention was prescribed for 15min, 5x/week to older adults with mild to moderate cognitive impairment with encouraging results in the measurement of the falls risk score measured by Fall Risk for Older People in Community (FROP-Com); and the postural stability measured by a functional reach test and computerised, dynamic balance, limit of stability test (Suttanon et al., 2013a).

The outcome measures used in each study were also variable. Outcome measures for postural stability can be divided into clinical and laboratory. The clinical outcome measures included measurement of static postural stability (e.g., single leg stance (s)); dynamic postural stability (e.g., functional reach, (cm)); and functional postural stability (e.g., chair leg squat (s), Timed Up and Go test (s), timed Sit to Stand (s), Performance Oriented Mobility Assessment (POMA) (scale-mild, moderate, severe), and Berg Balance Scale (BBS). Whereas the laboratory measures included static outcomes (e.g., quiet standing (centre of pressure, sway velocity, degrees/s)); dynamic outcomes (e.g., limit of stability (movement velocity, degrees/s)); and functional postural stability (e.g., walking (speed, m/s)). The falls-related outcome measures were reported by using subjective falls incidents reports, Activity-specific Balance Confidence (ABC scale), falls efficacy scale, PPA (Suttanon et al., 2013a) and Fall Risk for Older People in Community (FROP-Com) (Suttanon et al., 2013a). The most commonly used of all these measures was TUG test (eight studies) to measure functional postural stability (Ahn & Kim, 2015; Claire et al., 2016; de Andrade et al., 2013; Hernandez et al., 2010; Pedroso et al., 2012; Ries et al., 2010; Rolland et al., 2007; Suttanon et al., 2013a) and Berg Balance Scale (seven studies). Significant changes were reported in all of these measures (p < 0.05) except for functional postural stability in two studies measured by the TUG test (Pedroso et al., 2012; Rolland et al., 2007) and static postural stability in one study measured by the single leg stance test (Rolland et al., 2007). In the single case study with an older adult with severe cognitive impairment, an individualised exercise programme improved the postural stability and mobility score measured by Berg Balance Scale and by Performance Oriented Mobility Assessment (POMA), respectively, and the incidence of falls was reduced from 2 to
none (Mirolsky-Scala & Kraemer, 2009). However, this study was conducted in one participant and the duration of the study was only 4 weeks. Although the participant was with severe cognitive impairment, the improvement may have been due to the intensive one-to-one intervention.

From this review it can be seen that there is still limited evidence for exercise–based interventions that aim to improve postural stability to prevent falls among older adults with Alzheimer’s disease. This brief review located six published RCTs, the majority being pilot and feasibility studies. The review found heterogeneity in the characteristics of the included participants and in the protocols of intervention programmes thus limiting a reasonable orcomputable conclusion. The sample size of the majority of the studies was also small. However, the collective findings of all of the studies were positive in that they all indicated that postural performance of older adults with mild to moderate cognitive impairment who have been diagnosed with Alzheimer’s disease can be improved through a set of exercise programmes, irrespective of whether the populations were recruited from the community (Padala et al., 2017; Suttanon et al., 2013a), from programmes for seniors (de Andrade et al., 2013; Ries et al., 2010) or from nursing home residential care settings (Kim et al., 2016; Santana-Sosa et al., 2008).

While all of the community interventions demonstrated an improvement in postural stability (Kim et al., 2016; Öhman et al., 2016; Padala et al., 2017; Santana-Sosa et al., 2008; Suttanon et al., 2013a), the effect seemed to be moderated by the severity of the cognitive impairment. For instance, in a study with older adults with severe cognitive impairment (MMSE, mean (SD) = 8.8 (6.6) by Rolland et al. (2007), despite the participants having intensive (60min, 2x/week, 12 months) exercise, the results showed no significant difference in the components of functional and static postural stability measures by the TUG test and the single leg stance test. Although the postural stability measures did not show improvement, the programmes showed improvement in the activities of daily living component (p = 0.02). It could be that the health status of the participants, who were much more frail and staying in a nursing home residence, limits the achievement of significant improvement. In contrast, in the single case study by
Mirolsky-Scala (2009), after a less intensive programme (30min, 3x/week, 1month), a positive change in the score of Performance Oriented Mobility Assessment (POMA), Berg Balance Scale and the number of falls was recorded. While a case study, these results may be due to the highly participant-centred intervention that specifically focused on the disability measures of the individual selected for this study (Mirolsky-Scala & Kraemer, 2009). Positive change in functional stability, measured by Berg Balance Scale, was also found in the study by Kim et al. (2016). This study incorporated multi-components of cognitive training in additional to aerobic training among older adults with moderate to severe cognitive impairment who were living in a nursing home residence. These studies cautiously indicate that nursing home residents, with severe cognitive impairment, still derive benefit from an exercise programme (Kim et al., 2016; Mirolsky-Scala & Kraemer, 2009; Rolland et al., 2007).

Only two studies incorporated dual task activities in their protocol (de Andrade et al., 2013; Pedroso et al., 2012). The underlying theory is that, older adults with Alzheimer’s disease present with reduced executive function. Executive function is involved in the process of working memory that is important for planning and execution of movement (Rapp, Krampe, & Baltes, 2006). Disturbance to executive function and working memory could affect older individuals’ performance of activities of daily living (Brandt et al., 2009; Radanovic et al., 2009). In additional, postural stability studies, among older adults with mild to moderate Alzheimer’s disease, found that there is an association between dual task and risk of falls (de Andrade et al., 2014; Manckoundia et al., 2006; Suttanon et al., 2012a). Thus, the combination of postural control training with elements of cognitive stimulation offer new hope to improve stability while stimulating the brain, especially the frontal region.

The evidence for exercise to improve postural stability and to reduce falls in older adults with Alzheimer’s disease is less compelling than in healthy older adults as there is insufficient high quality evidence (Close et al., 2014; Guo, Tsai, Liao, Tu, & Huang, 2014; Kenny et al., 2011; Shaw, 2007). Thus more research is needed to evaluate the effectiveness of an exercise programme to improve postural stability. In particular,
consensus of appropriate exercise parameters, within the different specific components of the exercise programme, is required.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcome measures</th>
<th>Results which showed significant improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abreu and Hartley (2013)</td>
<td>Case study</td>
<td>n = 1</td>
<td>Salsa dance, 24 sessions, 12 weeks</td>
<td>-POMA</td>
<td>-POMA improved 5 points to 16/28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 1</td>
<td></td>
<td>-BBS</td>
<td>-BBS improved 19 points to 32/56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age = 83 years</td>
<td></td>
<td>-TUG</td>
<td>-TUG decreased 63s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population = AD, CHA</td>
<td></td>
<td>-10MWT</td>
<td>-Gait speed increased 0.08m/s to 0.29m/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SLUMS = 7/30</td>
<td></td>
<td>-6MWT</td>
<td>-6MWT improved 41.5m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration = 3 months</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Setting = NA</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ahn and Kim (2015)</td>
<td>Pre-post exp.</td>
<td>n = 23</td>
<td>1 group The experimental group performed UL and LL exercises – elastic band resistance exer. (warm up, resistance exercise, cool down)</td>
<td>-CLS,</td>
<td>-SLS improve sig. p &lt; 0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = NA</td>
<td></td>
<td>-SLS</td>
<td>-CLS improve sig. p &lt; 0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age = 74.21 (6.09) years</td>
<td></td>
<td>-TUG,</td>
<td>-2MW steps number increase sig p &lt; 000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population = AD MMSE = 10-19</td>
<td></td>
<td>-2MW test, and gait ability</td>
<td>-GS improve sig. p &lt; 0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration = 5 months</td>
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<td></td>
<td></td>
<td>Setting = NA</td>
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</tr>
<tr>
<td>de Andrade et al. (2013)</td>
<td>Pre-post exp.</td>
<td>n = 30</td>
<td>2 groups 1.Intervention group -n = 14; aged 78.6 (7.1) years, multimodal exercise (warm-up, aerobic, dual task, strengthening exer.)</td>
<td>-COP (4cond.²)</td>
<td>-less body sway (P = .04, partial n²= 0.04) during the dual tasks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F = 24</td>
<td></td>
<td>-TUG,</td>
<td>-TUG, Wilks k = 0.324, F(6,19) = 6.621, P = .001, partial n² = 0.676, reducing number of steps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population = AD CDR = Mild to moderate CI</td>
<td></td>
<td>-30-s STS</td>
<td>(F(1,24) = 8.70, P &lt; .001) -30-s STS, greater gains in lower limb strength than</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration = weeks</td>
<td></td>
<td>-SRT</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Setting = Kinesiotherapy programme for seniors</td>
<td></td>
<td>-BBS</td>
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</tbody>
</table>

*(²) Adapted from the original study.
Claire et al. (2016) RCT (abstract) n = 40
Age = 80 years
Population = AD
MMSE = NA
Duration = 8weeks
Setting = NA
2 groups
1. Trained group
- regular prescribe medications
- light physical activity or walking
- 15-55min, 2-3x/weeks, 8weeks
2. Control group
- did not participate in any kind of training
-POMA
-TUG
-a significant (p < 0.05) improvement in the POMA (T1: 19.5 (4.2) s; T2: 20.1 (4.1) s),
-a significant decrease in the completion time of the TUG (T1: 23.1 (8.1) s; T2: 19.5 (6.1) s)

Hernandez et al. (2010) LS (abstract, full paper in Portuguese) n = 16
F = NA
Age = 78.5 (6.8) years
Population = AD
Duration = 6months
Setting = NA
2 groups
1. Trained group, n = 9
- exercised systematically for 6 months
- MMSE = 16.4 (6.7)
2. Control group
- n = 7
- MMSE = 14.2 (5.1)
-BBS
-TUG
-AGIBAL
-AAHPERD
Mann Whitney = p=0.003 (TUG and BBS)

Kim et al. (2016) RCT n = 33
F = 25
Age = 81.5 (6.6) years
Population = AD
MMSE = 14.8 (4.4)
Duration = 6months
2 groups
1. Intervention group, n=19
- warm up and stretching, lower-limb aerobic exercise using a grip strength
-BBS
-grip strength p = 0.02 6/10
-BBS significantly increased p=0.04
<table>
<thead>
<tr>
<th>Setting = Nursing home</th>
<th>Terasuerugo®, cool down and relaxation. -60min, 5x/week, 6months</th>
</tr>
</thead>
<tbody>
<tr>
<td>-MCP (music, art, horticulture, handicraft, recreational, stretching, laughing therapy, and activity therapy. -60min, 2x/day/week, 6months</td>
<td></td>
</tr>
</tbody>
</table>

2. Control group, n = 14
- received only the MCP
- 60min, 2x/day/week, 6months

<table>
<thead>
<tr>
<th>Mirolsky-Scala and Kraemer (2009)</th>
<th>CS</th>
<th>n = 1</th>
<th>F = 1</th>
<th>Age = 85 years</th>
<th>Population = AD</th>
<th>CDR = 3 (severe)</th>
<th>Duration = 4 weeks</th>
<th>Setting = LTC</th>
<th>The PT fall management programme included LE and core therapeutic exercise, balance, gait, and assistive device training, and caregiver instruction in the form of a FMP</th>
<th>-POMA</th>
<th>-BBS</th>
<th>-Fall incidence</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td>-POMA score increased from 8/28 to 16/28</td>
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<td>-BBS score from 7/56 to 19/56</td>
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<td></td>
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<td>-falls decreased from 2 to 0</td>
<td></td>
<td></td>
<td>-falls decreased from 2 to 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Öhman et al. (2016)</th>
<th>RCT (abstract)</th>
<th>n = 194</th>
<th>F = NA</th>
<th>Age = NA</th>
<th>Population = AD</th>
<th>MMSE = NA</th>
<th>Duration = 12months</th>
<th>Setting = NA</th>
<th>2 groups</th>
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<td>1. Mild CI</td>
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<td>-exercise</td>
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<td>-2x/week, 12months</td>
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<td>2. Severe CI</td>
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<td></td>
<td></td>
<td></td>
<td>-fall incidence</td>
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</tbody>
</table>

- Effective in preventing falls among patients with advanced AD, with an incidence rate ratio of 0.47 (95% CI 0.37, 0.60; p < 0.00)
Padala et al. (2017)  
RCT, PS (abstract)  
n = 30  
F = NA  
Age = 73 (6.2) years  
Population = AD  
MMSE = NA  
Duration = 2 months  
Setting = community  
2 groups  
1. Intervention group  
- Wii-Fit  
- 8 weeks  
2. Control group  
- walking  
- 8 weeks  
- Home-based exercises were performed under caregiver supervision for 8 weeks  
-BBS  
- ABC scale  
- Falls efficacy scale  
-Sig. greater improvement (average inter-group difference [95% CI]) in the Wii-Fit group compared to the walking group in BBS (4.8 [3.3, 6.2], p < 0.00)  
- Improvement was sustained at 16 weeks (3.5 [2.0–5.0], p < 0.00)  
-Pedroso et al. (2012)  
LS  
n = 21  
F = NA  
Age = 78.3 (7.4) years  
Population = AD  
MMSE = 20.1 (4.6)  
Duration = 48 months  
Setting = NA  
2 groups  
1. Intervention group, n = 10  
I = dual task PA (coordination, aerobic resistance, flexibility, balance and agility, cognitive task)  
Frequency = 3x/week, non-consecutive days  
Durations = 60 minutes  
2. Control Group, n = 11  
-BBS  
-TUG  
-Sig. greater improvement 6/10  
-BBS-ANOVA-interaction between groups and moments p = 0.04  
-TG had better performance tested by BBS only p= 0.03 (pre-post)  
-reduction in number of falls
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Sample Size</th>
<th>Gender</th>
<th>Age (Mean, SD)</th>
<th>Population</th>
<th>MMSE (Mean, SD)</th>
<th>Duration</th>
<th>Setting</th>
<th>Interventions</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ries et al. (2010)</td>
<td>PS, pre-post exp. study</td>
<td>n=5</td>
<td>F=1</td>
<td>Age = range 81-93 years</td>
<td>Population=AD</td>
<td>MMSE= 18-24</td>
<td>Duration=4 weeks</td>
<td>Setting=adult care centre</td>
<td>-Group exercise -Balance activities were functional and concrete, and the intervention was organized into constant, blocked, massed practice. -45min, 2x/week, 8weeks</td>
<td>-n = 5, BBS improved, ≥ 6.4 points (MDC&lt;sub&gt;90&lt;/sub&gt;) -n = 3, TUG improved, ≥ 4.09 seconds (MDC&lt;sub&gt;90&lt;/sub&gt;) -n=3, GS increased ≥ 9.44 cm/sec (MDC&lt;sub&gt;90&lt;/sub&gt;)</td>
</tr>
<tr>
<td>Ries et al. (2015)</td>
<td>Quasi-exper</td>
<td>n = 22</td>
<td>F = 14</td>
<td>Age = 78.6 (11.3) years</td>
<td>Population = AD</td>
<td>MMSE = 14.8 (6.8)</td>
<td>Duration = 12 weeks</td>
<td>Setting = day health</td>
<td>Group training, 45min, 2x/w</td>
<td>-BBS -TUG -SSGS -FGS</td>
</tr>
<tr>
<td>Rolland et al. (2007)</td>
<td>RCT</td>
<td>n=134</td>
<td>F=101</td>
<td>Age = 83 (7.4) years</td>
<td>Population = AD</td>
<td>MMSE = 8.8 (6.6)</td>
<td>Duration = 12months</td>
<td>Setting = Nursing home</td>
<td>2 groups 1.Intervention group, n=67 -MMSE = 9.7 (6.8) -Collective exercise: walking, LE resistance and balance exercises -60 min, 2x/week; 12 months -Group: 2–7 (mean, 5.2); by: OT</td>
<td>-TUG -SLS -GS</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>N</td>
<td>F</td>
<td>Population</td>
<td>MMSE Range</td>
<td>Duration</td>
<td>Setting</td>
<td>Intervention Details</td>
<td>Control Details</td>
<td>Outcome Measures</td>
</tr>
<tr>
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</tr>
<tr>
<td>Santana-Sosa et al. (2008)</td>
<td>RCT</td>
<td>24</td>
<td>15</td>
<td>AD</td>
<td>range 18-23</td>
<td>3 months</td>
<td>Residential nursing home</td>
<td>2 groups</td>
<td>-routine medical care</td>
<td>4/10</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1. Intervention group, n = 16</td>
<td>-individualised, walking, stretching exercises, joint mobility exercises, resistance training and coordination/balance exercises (with music)</td>
<td>-75 min, 3x/week, 12 weeks</td>
</tr>
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<td></td>
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<td></td>
<td>2. Control group, n = 8</td>
<td>-routine nursing/medical care</td>
<td>-No changes (p &gt; 0.05) were found in the control group</td>
</tr>
<tr>
<td>Suttanon et al. (2013a)</td>
<td>FS, pilot RCT</td>
<td>40</td>
<td>25</td>
<td>AD</td>
<td>21.28 (4.59)</td>
<td>6 months</td>
<td>Community</td>
<td>1. Intervention group, n = 19</td>
<td>-individually tailored balance, strengthening and walking exercise programme (PT)</td>
<td>-FROP-Com, -PPA, -FR, -Step test, -TCS, -TUGman, -TUGcog, -mCTSIB, -LOS, -walking, -SQT, -STS</td>
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<td></td>
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<td></td>
<td>2. Control Group, n = 21</td>
<td>-home-based education programme (OT)</td>
<td>-FROP-Com, B coefficient (95% CI) -2.58 (-4.49, -0.66, p = 0.01) -FR, B coefficient (95% CI) 4.18 (1.57, 6.79), p = 0.00 -LOS (movement velocity), B coefficient (95% CI) -0.57 (-1.04, -0.11), p = 0.02</td>
</tr>
</tbody>
</table>
Notes. 2MST, 2-min step test; 6MWS, 6 minute walking speed; 6MWT, 6 minute walking test; 8-ft UG, 8-ft up-and-go; 10MWT, 10 meter walk test; ABC scale, Activity-specific Balance Confidence scale; ACT, arm curl test; ADL, activity of daily living; AGIBAL, the agility/dynamic balance; AAHPERD, the American Alliance for Health, Physical Education, Recreation and Dance; BST, back scratch test; BBS, Berg Balance Scale; CI, cognitive impairment; CDT, Clock Drawing Test; cond., conditions; CG, control group; CHA, cerebral haemorrhagic aneurysm; CLS, chair leg squat; CSR, chair sit-and-reach; FAB, Frontal Assessment Battery; FGS, fast gait speed; TG, training group; TUG, Timed Up and Go test; I, intervention; PA, physical activity; PS, pilot study; PT, physiotherapy/physical therapy; LE, lower extremities; FMP, functional maintenance programme; POMA, Performance Oriented Mobility Assessment; QoL, quality of life; F, feasibility study; GS, gait speed; LTC, long term care; FR, functional reach test; PPA, Physiological Profile Approach; FROP-Com, Falls Risk for Older People-Community; TCS, timed chair stand; mCTSIB, modified clinical test of sensory interaction of balance; NA, not available; LOS, limit of stability; SQT, step quick turn; STS, Sit to Stand; SLS, single leg stance; SLUMS, Saint Louis University Mental Status; SSGS, Self-selected Gait Speed.

All values are mean (standard deviation) or as otherwise indicated.

4 conditions (Task 1, looking at the target with arms at sides; Task 2, looking at the target while counting backward from 30; Task 3, looking at the target and holding a tray; Task 4, looking at the target, holding a tray, and counting backward from 30
2.5.3 The Otago Exercise Programme as a basis for an exercise programme

The Otago Exercise Programme (OEP) was developed by a research team led by Prof. A. John Campbell from the Otago Medical School, University of Otago, New Zealand. This home-based programme aims to prevent falls in older adults aged 60 years and above, and includes individually tailored lower limb strength and balance retraining exercises on three days a week and a walking programme on alternate days prescribed and delivered by a physiotherapist or a nurse trained by a physiotherapist. The OEP has a manual which includes the evidence base for the programme, guidelines to implement the programme, a full list of exercises with pictures and written explanations, and a diary. The older adult is encouraged to exercise for at least 30 minutes, 3 times per week and walk 2 times per week. In the first two months, the physiotherapist visits on week 1, then on weeks 2, 4 and 8. Follow up phone calls are made weekly from week 9 for 3 months and continue monthly until completion of the programme at 12 months, to maintain motivation and discuss any problems (Campbell et al., 1997; Campbell et al., 2005; Thomas, Mackintosh, & Halbert, 2010). The degree of difficulty of the exercises is assessed and prescribed during the home visits. After 8 weeks, the older adult is encouraged to continue by themselves without the physiotherapist’s support (Campbell et al., 1997; Campbell et al., 2005; Thomas et al., 2010).

The targeted muscles for strengthening exercises are the knee extension (quadriceps), hip extension (gluteal maximus), hip abduction (gluteal minimus) and knee flexion (hamstring) muscles. The balance retraining exercises are: single leg standing, tandem walking, side walking, backward walking, figure of eight walking and stair climbing. The exercise programme also includes functional mobility exercises, for instance, the sit to stand exercise (Campbell et al., 1997; Campbell et al., 2005; Thomas, Mackintosh, & Halbert, 2010).

The OEP is easy and simple to follow and has a high compliance over 12 months. In a systematic review by Thomas et al. (2010), it was found to significantly reduce fall rates in older adults aged 81.6 (SD 3.9) years measured by the rate of falls and injurious falls (incidence rate ratio = 0.68, 95% CI 0.56, 0.79) (Thomas et al., 2010). It is considered a cost effective approach to prevent falls that requires minimal investment.
to implement (Thomas et al., 2010). In the studies included in the meta-analysis, the populations were community-dwelling older adults with a mean (SD) age of 82 (4) years. In order to include results from more recent studies not included in the Thomas and colleagues’ review (Thomas et al., 2010), I searched the literature for articles published from 2010 until recently and found another five studies (Kyrdalen et al., 2014; Lindop, Skelly, & Smith, 2012; Suttanon et al., 2013a; Waters, Hale, Robertson, Hale, & Herbison, 2011; Yang et al., 2012). Table 2.7 illustrates details these five studies.

The programme was adapted by Age Concern Otago to be a peer-led3, group-based, exercise programme named ‘Steady As You Go’ (SAYGo). The targeted participants were healthy older adults within the age range of 65-94 years old (Waters et al., 2011). The initiative was developed in 2002 by a team from the University of Otago School of Physiotherapy and Age Concern Otago in conjunction with the Accident Compensation Corporation and was administered fully by Age Concern Otago. More than 200 peer-led groups are currently running in the lower South Island, New Zealand. The leaders are trained by professional instructors to ensure the effectiveness and the safety of exercise delivery. The programme is held for one hour, once a week for 10 weeks. The facilities used for delivery of the classes include church and community halls throughout the Otago region. An evaluation of the SAYGo Programme found a 29% decrease in fall risk for those in the peer-led group compared with a comparison group (incidence rate ratio [IRR], 0.73; CI 95% 0.48, -1.1; p = 0.07) (Waters et al., 2011). In this SAYGo study, the comparison group were doing seated aerobic exercises.

The group-based OEP has started to be recognised as being as beneficial as an individual home-based OEP. Kyrdalen et al. (2014) evaluated the effectiveness of a home-based OEP and a group-based OEP for 12 weeks. The prescription of exercise for the home-based programme followed the guidelines from the original (Kyrdalen et al., 2014). For the group-based OEP, groups of 4-8 participants carried out 45 minutes of exercises, twice weekly. The exercise programme was found to be effective in

3 Peer-led is a person or persons from a similar age range who coordinate and work as exercise trainer(s) for a group doing the exercise programme.
improving balance when tested by the Berg Balance Scale (95% CI 0.7, 5.8, p = 0.01) and muscle strength when measured by the 30 second Sit to Stand test (p = 0.00), among older adults with the mean (SD) age of 83 (6) years (Kyrdalen et al., 2014).

In addition to the modifications for both group and individual OEP, the programme has also been specifically used in older adults with mild balance dysfunction (Yang et al., 2012), Parkinson’s disease (Lindop et al., 2012) and mild to moderate Alzheimer’s disease (Suttanon et al., 2013a). In these three studies, the aim was to evaluate the OEP with respect to improving postural stability as opposed to reducing falls per se. Two studies considered the homed-based (Suttanon et al., 2013a; Yang et al., 2012) and one study the group-based OEP (Lindop et al., 2012).

The parameters of Otago Exercise Programme that were used varied between 5-8 exercises per session, a walking programme for 30 minutes, 5 times per week for 6 months (Yang et al., 2012), 75 minutes of a group exercise weekly, for 8 weeks (Lindop et al., 2012), 20 minutes of strengthening, balance and walking exercises, 5 times per week for 6 months (Suttanon et al., 2013a). Based on these three studies, for participants with postural stability or/and cognitive impairment, there is no consensus in regard to the minimal duration, intensity and frequency of the OEP in order to show benefits in regard to postural stability. Moreover, only the study by Suttanon et al. (2013) researched the OEP being conducted among older adults with Alzheimer’s disease.

A RCT by Yang et al. (2012), which included a 6-month Otago Exercise Programme, involved studying the Visual Health Information Balance and the Vestibular Exercise Kit programme being conducted with 165 older adults with a mean age of 81 years (Yang et al., 2012). The participants were categorised as having mild balance dysfunction. This was determined by low scores on the Functional Reach Test, Step Test, Five-Time Sit to Stand test and 6 tests on the NeuroCom Balance Master force platform with long plate. The findings from the study showed that the OEP group improved (mean difference, 95% CI) their postural stability as measured by the Step Test (2.10 steps in 15 seconds, 95% CI 1.17, 3.02), hip abductor muscle strength (0.02,
95% CI 0.01, 0.03), the Functional Reach Test (2.95 cm, CI 95% 1.75, 4.15), and gait step width (2.17 cm, 95% CI 1.23, 3.11) (Yang et al., 2012).

In the study by Suttanon et al. (2013), 40 participants with a mean (SD) age of 82 (6) years, with mild to moderate Alzheimer’s disease, were randomised to either the OEP and or the home-based education programme (Suttanon et al., 2013a). The researchers used a comprehensive set of laboratory and clinical postural stability measures and found that the OEP was feasible, safe and provided benefits. They reported improved balance, measured by the functional reach test (p = 0.00), improved limit of stability (p = 0.02) and reduced falls risk, tested by the Fall Risk for Older People in Community version (FROP-Com) (B coefficient = -2.58 (CI 95% -4.49, -0.66, p = 0.01) in older adults with mild to moderate Alzheimer’s disease (Suttanon et al., 2013a).

Lindop et al. (2012) evaluated the effectiveness of the OEP in a small sample (n = 26) of individuals with Parkinson’s disease and found improvement in postural stability measured by the Berg Balance Scale, with a median improvement score of 4.5 (Mann Whitney U = 5 216, z = 2.23, p < 0.05 two tailed) (Lindop et al., 2012). However, further detail and information could not be retrieved because this study had been reported in a conference abstract. Still these limited results suggest that the OEP is suitable to be used with older adults with neurological problems including with older adults with Alzheimer’s disease.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
<th>Participants</th>
<th>Parameters OEP</th>
<th>Results</th>
<th>Pedro Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yang et al. (2012)</td>
<td>RCT</td>
<td>n = 165, Population = mild balance dysfunction</td>
<td>6 months</td>
<td>FRT, Step test, ms strength, gait step improved</td>
<td>7/10</td>
</tr>
<tr>
<td>Suttanon et al. (2013a)</td>
<td>RCT</td>
<td>n = 40, Age = 81.9 (5.72) years, Population = AD, MMSE = 21.28 (4.59)</td>
<td>Individual</td>
<td>FRT, LOS, FROP-com improved</td>
<td>6/10</td>
</tr>
<tr>
<td>Lindop et al. (2012)</td>
<td>Conf. abs.</td>
<td>n = 26, Population = Parkinson’s disease</td>
<td></td>
<td>BBS improved</td>
<td>-</td>
</tr>
<tr>
<td>Kyrdalen et al. (2014)</td>
<td>RCT</td>
<td>n = 125, Age = 82.5 (5.7) years, Population = older adult at ROF</td>
<td>4-8/group 45min, 2x/w, 12w</td>
<td>BBS, 30s STS, SF36 improved</td>
<td>6/10</td>
</tr>
<tr>
<td>Waters et al. (2011)</td>
<td>Quasi-exp.</td>
<td>n = 118, Age = 75.5 years, Population = older adult at ROF</td>
<td>Peer-led group 1x/w, 10w</td>
<td>Decrease in fall risk [IRR], 0.73; CI 95% = 0.48, -1.1; p = .07</td>
<td>-</td>
</tr>
</tbody>
</table>

**Notes.** AD, Alzheimer’s disease; abs, abstract; BBS, Berg balance scale; Conf., conference; FROP-com, falls risk for older people in community; FRT, functional reach test; LOS, limit of stability; MMSE, mini mental state examination; ms, muscle; N/A, not available; exp., experimental; OEP, Otago Exercise Programme; ROF, risk of fall; w, week; SF36, 36 items short form survey; STS, Sit to Stand; RCT, randomised controlled trial.

All values are mean (standard deviation) or as otherwise indicated.
2.5.4 Rationale and study position of an intervention to reduce risk of falling

As recommended by the American College of Sport Medicine, exercise-based interventions to improve postural stability in older adults should include exercises that target flexibility, strength, balance and aerobic fitness (Nelson et al., 2007). As discussed in this review, there is limited evidence for specific exercises programmes to achieve this aim in older adults with Alzheimer’s disease. For this thesis, I chose to base my exercise intervention on the OEP because it is an international renowned, evidenced-based programme for falls prevention in community-dwelling older adults, found to be effective in individual and group settings. However, a fundamental concern I had was how to deliver such a programme to optimise engagement and participation for older adults with Alzheimer’s disease. To address this issue, I undertook a qualitative study (Chapter 6) to explore what older adults with mild to moderate cognitive impairment perceived to be the best composition and delivery of an exercise programme, to improve postural stability for themselves so as to optimise adherence. I also was unsure as to whether the Otago Exercise Programme would target factors that specifically impact postural stability in older adults with Alzheimer’s disease. As these factors have not yet been identified, I systematically reviewed the literature (see Chapter 4) with this focus in mind, with the aim of modifying the OEP as appropriate.

2.6 Interview approach in designing an intervention

The evidence that practice in physiotherapy for postural instability interventions is based on, is largely dominated by quantitative studies. In clinical practice however, eliciting information from clients is not limited to quantitative measures, such as the standardised outcome measurement, but also includes history taking to gain the client’s perspective of their current problem thus gathering as much as information as needed for effective treatment. Moreover, qualitative research has been recognised as being as important as quantitative research in providing evidence for physiotherapy practice (Gibson & Martin, 2003). Research on client perspectives empowers decision making, prioritising what is important in intervention delivery (Thornquist, 2001). Each individual brings their own culture and values to the intervention; there is no one specific intervention appropriate for all. Integrating the best existing evidence, client
preferences and the clinician’s experience and expertise are thus equally important to achieve the best results for clients.

In person-centred dementia care, the practice is similar to the guidelines in evidence-based practice. There are four principles of care highlighted in person-centred care: 1) valuing persons with dementia and their support person; 2) treating them as individuals; 3) aim for understanding what they need from the perspective of the person who is living with dementia; and 4) building a positive social atmosphere where the person living with dementia can experience good health and wellbeing (Brooker, 2003). Clare et al. (2002) further defined person-centred dementia care as managing individuals with dementia by understanding their experience within the context of psychological responses and social adaptation; therefore, the support could be tailored to the individual’s needs (Brooker, 2003; Clare, 2002).

In the process of adopting a person-centred approach to the development of a fall prevention exercise intervention for older adults with cognitive impairment, a qualitative study exploring their perspective on exercise prescription was, thus, part of this thesis’ research agenda.

2.6.1 Evidence from literature for optimal intervention delivery

To provide an evidence base for optimal intervention delivery, I reviewed current literature to address the following questions with regard to older adults with cognitive impairment: (1) what were participants’ perceptions of the exercise programmes or physical activity participation, (2) the reasons for, and (3) the barriers to participation to physical activity / exercise programmes. Table 2.8 illustrates briefly the five articles that I found (Cedervall & Åberg, 2010; Suttanon et al., 2012; Chong et al., 2014; Malthouse & Fox, 2014; Yu & Swartwood, 2012). Three articles explored perception of physical activity based on life experience in engaging with physical activity or exercises, and the remaining two articles explored perceptions following participation in an individually tailored, exercise intervention programme (Suttanon et al., 2012) and in a group aerobic, exercise programme (Yu & Swartwood, 2012)).
Table 2.8 Characteristics of studies reviewed in this chapter (qualitative studies)

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>Participants with AD</th>
<th>Caregiver</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedervall and Åberg (2010)</td>
<td>Case study design</td>
<td>n = 2</td>
<td>n = 2</td>
<td>Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>One-to-one semi-structured interviews</td>
<td>Age, year = range 63-74 MMSE = 20 (SD not reported)</td>
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<tr>
<td>Chong et al. (2014)</td>
<td>Focus group interviews</td>
<td>n = 11 Age, year = 76 (36.4) MMSE = 22.3 (5.5)</td>
<td>NA</td>
<td>Not reported</td>
</tr>
<tr>
<td>(Malthouse &amp; Fox, 2014)</td>
<td>One-to-one semi-structured interviews</td>
<td>n = 5 Age, year = range 64-84 MMSE = range 18-21</td>
<td>n = 5 Age, year = range 64-84</td>
<td>Thematic analysis</td>
</tr>
<tr>
<td>Suttanon et al. (2012)</td>
<td>Phenomenological theoretical framework. One-to-one semi-structure interviews (post)</td>
<td>n = 10 Age, year = 75-89 MMSE = range 16-28</td>
<td>n = 9 Age, year = range 57-85</td>
<td>phenomenological</td>
</tr>
<tr>
<td>Yu and Swartwood (2012)</td>
<td>Mixed method study design; proof of concept focus group (post)</td>
<td>n = 10 Age, year = range 64-91 MMSE = range 12-24</td>
<td>n = 10 Age, year = 65</td>
<td>Content analysis</td>
</tr>
</tbody>
</table>

Notes. AD, Alzheimer’s disease; MMSE, Mini-Mental State Examination; NA, not available, SD, standard deviation. All values are mean (standard deviation) or as otherwise indicated.

To collect data, three studies used face-to-face interviews (Cedervall & Åberg, 2010; Malthouse & Fox, 2014; Suttanon et al., 2012) and two studies used focus groups (Chong et al., 2014; Yu & Swartwood, 2012). Data analysis was guided by phenomenological (Suttanon et al., 2012), thematic (Cedervall & Åberg, 2010; Malthouse & Fox, 2014) and content approaches (Yu & Swartwood, 2012). One study
reported that the analysis was facilitated by NVivo software without further explanation of the method used for the data analysis (Chong et al., 2014).

The findings of this literature review are described below, under two categories, in Table 2.9: (1) programme characteristics (Cedervall & Åberg, 2010; Chong et al., 2014; Malthouse & Fox, 2014; Suttanon et al., 2012; Yu & Swartwood, 2012) and (2) the reasons for, and barriers to, participation.

Table 2.9 Themes that influenced the decision to participate in an exercise programme

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<tbody>
<tr>
<td>Programme</td>
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<tr>
<td>Leisure activity/lifestyle</td>
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<tr>
<td>Financial</td>
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<tr>
<td>Safety</td>
<td>√</td>
<td>√</td>
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<tr>
<td>Perceived benefits</td>
<td>√</td>
<td>√</td>
<td>√</td>
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<td>√</td>
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<tr>
<td>Social</td>
<td>√</td>
<td>√</td>
<td>√</td>
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<tr>
<td>Barriers</td>
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<tr>
<td>Disease progression/memory/ Difficulties in finding one’s ways</td>
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<tr>
<td>Behaviour/ attitude/ personality/ motivation</td>
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<tr>
<td>Walking ability</td>
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<tr>
<td>Weather</td>
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</tbody>
</table>
Programme characteristics

There were diverse opinions as to what the programme characteristics should be. Even though two studies concluded that a group exercise programme was most desirable, the content of the programme should be individually tailored (Chong et al., 2014; Malthouse & Fox, 2014). An individually tailored programme should cater for the needs, interests and abilities of each participant (Malthouse & Fox, 2014). A programme conducted by Suttanon et al. (2012) used the OEP, which is based on a set of exercises for strength and balance training (Suttanon et al., 2012). These exercises were simple and easy to follow, and as a result the retention rate of the programme was high. Chong et al. (2014) also identified that older adults with Alzheimer’s disease prefer to have light and simple physical activities to do, such as walking (Chong et al., 2014). Walking was considered desirable as it is a crucial part of daily activity that keeps a person mobile (Chong et al., 2014). Involvement of the health care provider, for example a physiotherapist, was also considered important to keep participants motivated to engage with the physical activity (Suttanon et al., 2012). There was, however a gender difference to the preferences of instructors in a study by Chong et al. (2014); female participants preferred to exercise with a friend whereas males seemed to prefer a personal trainer (Chong et al., 2014).

The reasons for, and barriers to, participation

Health benefit was the main reason why older adults with Alzheimer’s disease participated. Exercise or physical activity was deemed important for health, for instance, to maintain or improve cognition or help reduce its deterioration (Chong et al., 2014; Yu & Swartwood, 2012), to affect mood (Cedervall & Åberg, 2010; T. W. H. Chong et al., 2014; Malthouse & Fox, 2014), for enjoyment (Cedervall & Åberg, 2010), and for its effects on the body, for example, reducing weight and improving flexibility and strength (Malthouse & Fox, 2014; Yu & Swartwood, 2012). In a study by Suttanon et al. (2012), maintaining an exercise recording sheet increased self-motivation to keep participating in the programme.

The perceived health benefit was expanded by the value derived from the social interaction. Being in a group, where everyone understood the specific needs of older
adults with Alzheimer’s disease, enabled participants to feel comfortable and thus enjoy doing the activity more. The value of social interaction and relationship was important. Understanding the disease, their behaviour and changes gave them a sense of personhood especially coming from the other people in the community (Malthouse & Fox, 2014). In an earlier study exploring the feelings of people who have been diagnosed with dementia, the effects of these feelings resulted in a high chance of the older person withdrawing from society, especially as the disease progressed (Husband, 2000). More recent studies found that people with Alzheimer’s disease enjoyed the social relationships they experienced while doing physical activity or exercise (Cedervall & Åberg, 2010; Chong et al., 2014; Malthouse & Fox, 2014; Yu & Swartwood, 2012).

Safety was another influential factor in the decision to participate in physical activity or exercise. As mentioned before, people with Alzheimer’s disease wanted physical activity that was simple as it was perceived to be safer. The selection of more challenging physical activities brought up safety concerns. For example, walking was considered simple but if unsupervised in the community, participants expressed concerns with difficulties in finding their way back after a walk (Cedervall & Åberg, 2010). This caused carers to feel guilty and insecure about leaving those they supported to walk alone or to leave them alone at home (Cedervall & Åberg, 2010; Malthouse & Fox, 2014). These studies suggested that, while there are limitations in cognition, older adults with cognitive impairment are willing to do outdoor activities, such as walking (Chong et al., 2014), but there have to be strategies employed by which they can do this safely.

The challenges to physical activity / exercise participation were mostly related to disease progression, particularly as symptoms became more noticeable, for example, fatigue, the need of more sleep and behavioural changes (Cedervall & Åberg, 2010; Malthouse & Fox, 2014). The feeling of tiredness was also experienced by the caregivers. They said, as the disease progressed, the responsibility doubled, doubling the amount of energy needed to take care of everything, including household chores and taking care of their loved one (Malthouse & Fox, 2014). With disease progression
walk ability deteriorated. In a study by Cadervall and Anna (2010), one participant who had mild Alzheimer’s disease (MMSE score 21/30) indicated that he had declining postural stability and was experiencing staggering and falls. This increasing instability made it difficult for him to participate in physical activities or exercise (Cedervall & Åberg, 2010).

Environmental elements were also factors that influenced people’s decision to participate in a programme. The most common environment situation, that appeared to be a barrier to exercise, was weather (Chong et al., 2014; Malthouse & Fox, 2014; Suttanon et al., 2012).

2.6.2 Rationale and study position of the involvement of qualitative approach

There has been a paucity of research exploring the characteristics of an exercise programme that are important to optimise engagement and adherence from the perspective of the attendees. To date, I have found only two relevant studies (Chong et al., 2014; Malthouse & Fox, 2014). Chong et al. (2014) used focus group discussion to elicit opinion around the attributes of the ideal physical activity programme among older adults with cognitive impairment. The findings were: all in a focus group discussion, regardless of their cognitive status (from normal cognition to mild cognitive impairment with Alzheimer’s disease), preferred to exercise in a group but the exercises still needed to be tailored to individual needs and preferences. However, results from this study should be considered cautiously. Individuals with diagnosed cognitive impairment may not have expressed their true beliefs and values in a group discussion. Some group participants may also have been dominated by other group members, and thus not be able to fully express their opinions (Beyea & Nicoll, 2000). In the second study, Malthouse et al. (2014) explored the design of a physical activity intervention among older adults with Alzheimer’s disease and their caregivers (Malthouse & Fox, 2014). Even though the study used one-to-one interviews, the small numbers of participants (n = 5 older adults with Alzheimer’s disease, n = 5 caregivers) may limit the exploration of all parameters needed for the design of a physical activity intervention. Thus, the exploration of the physical activity intervention warrants more study. It is also important to explore how older adults with cognitive impairment
perceive their current postural stability to be, as this awareness would likely influence their engagement or not in interventions to improve postural stability. No study was found that explored this aspect, thus it became one of the aims of the thesis.

2.7 Summary

This chapter discussed the issues surrounding the aspect of Alzheimer’s disease and the risk of falling in this population. There was also discussion relevant to the gaps in the existing literature that need to be filled by further evaluation and exploration, specifically, in the area of postural stability and falls risk evaluation and intervention. There was evidence that further work and research is needed in these 4 areas: 1) evaluation of existing literature on the factors associated with falls; 2) the validity of the outcome measures: Physiological Profile Approach and Timed Up and Go test; 3) the perceptions of older adults with Alzheimer’s disease on their current stability performance and what would be the best way from their point of view to achieve that aim of improving postural stability and fall risk reduction; and, thus, 4) the incorporation of the results from the previous three to form an ideal exercise intervention for older adults with Alzheimer’s disease.

Chapter 3 discusses issues related to the methodology of my study, such as the challenges in Alzheimer’s disease research and the rationale for the choice of a mixed method study design.
CHAPTER 3

Methodology

3.1 Introduction
The previous chapter presented a broad overview of Alzheimer’s disease with a focus on the risk of falling and the theory of postural stability as two of the key components of this thesis. The chapter also discussed how the risk of falling and postural stability can be evaluated in the community, possible interventions to reduce this risk and improve postural stability among older adults with Alzheimer’s disease and how to maintain the adherence to whichever intervention is used.

This chapter discusses the challenges in the care of older adults with Alzheimer’s disease and within the research context, the need for complex interventions in this population, the rationale for the chosen research method, the philosophical and methodology considerations, the synthesising of the data and the ethical considerations. The broad aim of the thesis will be illustrated as well.

The term ‘participant’ in this chapter is defined as any individual that agrees to participate in the research. The term ‘support person’ is defined as any person that is central to the care of the person with Alzheimer’s disease. This person could be a next of kin, spouse, family / whānau\(^4\) member, primary caregiver or support worker, that is, anyone who is able to give information about the person with cognitive impairment that they care for.

\(^4\) an extended family or community of related families who live together. This is a word that is in common usage and from the Māori language, an official language of New Zealand.
3.2 Overview of method

In Chapter 2, evidence based practice in physiotherapy for postural instability interventions largely arises from quantitative studies. Both types of study design, quantitative and qualitative, are important for the emergence of a holistic intervention (American Physical Therapy Association, 2001; Gibson & Martin, 2003; Herbert & Higgs, 2004). The Medical Research Council also highlighted the importance of integration of qualitative and quantitative approaches to optimise informed decision making in practice (Campbell et al., 2007; Craig et al., 2008; Tashakkori & Teddlie, 2010). Research on client perspectives empowers decision making, prioritising what is important in intervention delivery (Thornquist, 2001). Each individual brings their own culture and values to the intervention; there is no one specific intervention appropriate for all. Integrating the best existing evidence, the clinician’s experience and expertise and the client choice are thus critically important to achieve the best results for clients (Zidarov, Thomas, & Poissant, 2013).

Research exploring the care of people with Alzheimer’s disease involves a complex data set that requires a valid and rigorous analytical approach, and that faces many methodological challenges (Campbell et al., 2000; Hubbard, Downs, & Tester, 2003; Ritchie, Terrera, & Quinn, 2015; Waugh et al., 2013; Weuve et al., 2015). The challenges begin with defining the scientific research questions, ethics and procedures required to obtain ethical approval, data collection, and end with the processes of data analysis and the drawing of the conclusion from the findings (Holland & Kydd, 2015; Weuve et al., 2015). Compounding the issue is the challenge of the reality of a deteriorating cognitive function as the disease progresses whilst the older adult with Alzheimer’s disease is participating in research and, yet, still ensuring the highest ethical standards are maintained. The issues surrounding ethics are discussed in the section sub-headed: Ethical considerations.

Defining the research questions requires strong background knowledge of the context of the respective area of interest. They should be timely, relevant and beneficial. There are two high priority concerns in Alzheimer’s research, to answer: 1) causal and 2) predictive inferences (Hernan, 2004). For example, the causal study aims to investigate
the effectiveness of the intervention, whereas the predictive study aims to estimate the prevalence, or to identify individuals at high risk, of falls. Many critiques suggest that causal inference should be answered by RCTs, and that this then requires a series of observational / quasi-experimental studies to inform the structure and designation of the RCT (Kitson, Harvey, & McCormack, 1998). The need for an observational study for the research questions explored in this thesis is discussed further in this chapter under the subheading: Complex intervention.

A logistical and practical issue in dementia care research is the time consuming assessment of potential participants, especially people with early cognitive impairment related to Alzheimer’s disease (Garand, Lingler, Conner, & Dew, 2009; Sherratt, Soteriou, & Evans, 2007; Vernooij-Dassen et al., 2005). The diagnosis for older adults with Alzheimer’s disease requires a person to undergo many medical investigations including a huge number of physical and neuropsychological assessments. By the time the diagnosis is confirmed, the fast progression of the disease can mean the individual has deteriorated from early mild cognitive impairment to a point where they are no longer eligible for inclusion in the research (Vernooij-Dassen et al., 2005).

In addition, researching older adults with early cognitive impairment who has been diagnosed with Alzheimer’s disease in the community is difficult (Holland & Kydd, 2015; McKeown, Clarke, Ingleton, & Repper, 2010). Older adults with a new diagnosis of Alzheimer’s disease may be reluctant to participate due to a perception of stigma (by self or others) if they include themselves within this group (Garand et al., 2009). This may be because this type of diagnosis has been understood by cultures to be a neuropsychiatric disorder, and one that is related to a mental health disorders. The stereotypical understanding of mental health disorders as having a definition that includes lacking in competency, being dangerous and personally irrelevant. This can lead to older adults with a relatively new diagnosis of cognitive impairment to feel that they have now been excluded by society (Garand et al., 2009). These are just a few of the reasons why this group of older adults may be reluctant to come forward and volunteer to be part of a study.
Another challenge in Alzheimer’s disease research is the utility of valid and reliable outcome measures. The psychometric properties of most measures of postural stability used in older adults with Alzheimer’s disease are unclear. To date, these outcome measures have typically been tested in the general older population. Recently a consensus statement on which measures are the most useful outcomes to evaluate postural stability was published; however, the applicability of this consensus to older adults with cognitive impairment remains unclear (Sibley et al., 2015).

Any single factor that influences the effectiveness of the intervention is very difficult to elicit from complex multi high level data. For example, this thesis utilised the phrase of, ‘an exercise programme to improve postural stability in older adults with Alzheimer’s disease’, the words ‘exercise programme’ themselves comprise many specific characteristics such as settings, duration, type of exercises and number of repetitions. As another example the phrase ‘postural stability’ may refer to the outcome measures and/or the performance. Together with the complexity of the condition ‘Alzheimer’s disease’ and the multicomponent complex nature of an exercise programme to improve postural stability, methodological challenges should be expected (Weuve et al., 2015).

Intervention research, aiming to improve postural stability in older adults with Alzheimer’s disease, will clearly involve complex, multi interacting components (Craig et al., 2008). The complex, multi-interacting components seen in the design and outcome of the intervention include: the intervention characteristics (Craig et al., 2008), outcome measures to evaluate postural stability (Bernhardt & Hill, 2005; Shumway-Cook & Woollacott, 2007) and older adults with Alzheimer’s disease as the research population (Weuve et al., 2015). Considering these multi-interacting components, attempting to elicit a single factor that influences the effectiveness of the intervention is difficult, therefore I categorised the intervention to improve postural stability in older adults with Alzheimer’s disease as a complex intervention.

Recognising the complexity and the context of physiotherapy care for a person with Alzheimer’s disease, my thesis employed a mixed methods study design (Tashakkori & Teddlie, 2010). But my design choice was also strongly guided by the Medical
Research Council’s (MRC) development of a complex intervention (Craig et al., 2008). That is, the need of multiple research inquires to be answered before the question of primary interest. Thus, I conducted four studies, with each study using a different method. The overarching aim of my thesis was:

- To develop, and evaluate the proof of concept of, an exercise programme intervention for older adults with Alzheimer’s disease to improve postural stability.

In order to achieve this aim, these three objectives first required my attention:

1. Identify the current evidence of postural instability and the associated factors which influence postural instability in older adults with Alzheimer’s disease.
2. Evaluate the psychometric properties of the Physiological Profile Approach and the Timed Up and Go test.
3. Explore the exercise parameters important to increase engagement for older adults with Alzheimer’s disease.

3.3 Background to the methods used in the thesis

3.3.1 Mixed methods research

Mixed methods research is a type of research that combines both qualitative and quantitative approaches to address multiple research inquiries in order to acquire the best set of evidence (Craig et al., 2008; Herbert & Higgs, 2004; Johnson & Onwuegbuzie, 2004; Johnson, Onwuegbuzie, & Turner, 2007; Shaw, Connelly, & Zecevic, 2010; Tashakkori & Teddlie, 2010). In mixed methods, the research questions are answered through integration of figures and text to discover the pattern (inductive) and by employing theories (deductive) (Mertens, 2014). Mixed method research was chosen as neither a qualitative nor a quantitative approach alone would be sufficient to address the aim and objectives of this thesis. Further, if both types of data are integrated, each method should complement each other, thus allowing a more robust analysis that takes advantage of each approach (Creswell, Klassen, Plano Clark, & Smith, 2011; Tashakkori & Teddlie, 2010).
Figure 3.1 Exploratory sequential concurrent and convergent mixed method (development phase of a complex intervention)
3.3.2 Selection of mixed methods research for this thesis

Figure 3.1 illustrates the model for exploratory, sequential, concurrent and convergent, mixed methods design procedures (Creswell et al., 2011; Leech & Onwuegbuzie, 2009; Tashakkori & Teddlie, 2010). The procedures and their characteristics are well established in the literature and the application of such methods provides data which can have huge implications to health sciences research (Creswell, 2012; Tashakkori & Teddlie, 2010).

Every study in this thesis answered a different research question as described in the following subheadings: Studies involved in concurrent mixed methods design and studies involved in convergent mixed methods design. The weight was given equally to all three studies in the first concurrent mixed methods design, which involved three independent data collection and analysis phases, with each study providing specific answers to the specific research question. After the completion of all three studies, the relevant findings were extracted and considered collectively to create the base knowledge for second phase of developing the complex intervention to improve postural stability in older adults with Alzheimer’s disease. At this second phase, the weight of the findings was given to the qualitative findings, supported by the quantitative results. Both methods, concurrent and convergent mixed methods, lie within an exploratory sequential mixed design, because the second phase was conducted following completion of the first phase. To answer the main aim of this thesis, integration from all findings from all studies was necessary and is demonstrated in the discussion. This mixed method type of research allows for the merging of multiple components during the synthesising phase. The details on the synthesising of the mixed methods data can be viewed on p. 89 of this chapter.

Studies involved in concurrent mixed methods design

1. **To identify the current evidence for postural stability and the associate factors which influence postural instability in older adults with Alzheimer’s disease:**
   
   A systematic review
A systematic search was conducted to identify the existing evidence related to such interventions. This was a first step in the phase of the development of a complex intervention as described on p. 86. A study of the literature to date found no consensus as to the best evidence for an intervention to improve postural stability in older adults with Alzheimer’s disease (Suttanon et al., 2010) and this suggested the need for further studies evaluating the effectiveness of interventions to prevent falls in older adults with Alzheimer’s disease (Burton et al., 2015; Hill, Hunter, Batchelor, Cavalheri, & Burton, 2015; Suttanon et al., 2010). The lack of evidence for the effectiveness of interventions to prevent falls in this population might be due to the fact that the interventions did not target specific components of the postural stability. Therefore, a systematic review that evaluated the evidence of postural instability and the factors associated with postural instability in older adults with Alzheimer’s disease was the first priority. This would allow me to identify what components should be targeted in an intervention. To my knowledge, no previous systematic review had been conducted to evaluate the evidence of postural stability being reduced in older adults with Alzheimer’s disease. In response to this gap in the evidence, I believed that evaluating the specific factors related to falls that are within the context of postural stability specifically in Alzheimer’s disease-health conditions, was a priority.

2. To evaluate the psychometric properties of the Physiological Profile Approach and the Timed Up and Go test.

The reliability and validity of outcome measures are the key indicators of the quality of the instruments. In health care services, improvement in the outcome following intervention is usually the major aim and thus, ideally, measures should be responsive to change. In the evaluation phase of the guideline for complex intervention, it is very important to choose a suitable instrument to evaluate the aim of the study (Craig et al., 2008). There are various types of outcome measures that can be used to evaluate postural stability, such as the Physiological Profile Approach and the Timed Up and Go test. I choose these two clinical outcome measures as they are feasible and easy to use in a community setting. However, the validity and reliability of these outcome measures in people with Alzheimer’s disease were unclear. Therefore, I employed a
quantitative study design to evaluate the concurrent validity of these two clinical outcome measures against tests with a supposedly more objective laboratory outcome measure, computerised posturography. Further, sensitivity and specificity of these clinical outcome measures and the cut off point to evaluate risk of falls were calculated. Evaluation of the sensitivity and specificity of clinical outcome measures can enable small trials to provide meaningful findings during the development of interventions (Campbell et al., 2007). Thus, the potential health benefits of the exercise programme in the final study (details in p. 84) could be evaluated.

3. To explore the best way to deliver an exercise programme to improve postural stability in older adults with Alzheimer’s disease.

The Medical Research Council recommends the need to conduct a new study during the development phase to develop the theory for complex interventions (detailed in p. 86). The development phase needed to attempt to arrive at a theoretical understanding of change process that was expected to occur. One of the suggested methods is to conduct a qualitative study. The qualitative study in Chapter 6 of the thesis, offered participants an opportunity to voice their opinions and express their views about their experience of living with Alzheimer’s disease, and how this influenced their preferences for a programme designed to improve postural stability. In other words, the study aimed to explore what participants considered to be an “ideal” programme for them. The presence and the impact of Alzheimer’s disease however needed to be considered when selecting the most appropriate qualitative approach.

There are various types of the qualitative approaches, such as Grounded Theory and the General Inductive Approach, that aim to generate theory which will help explain practice or provide a framework for further research (Creswell, 2012; Thomas, 2006). However, in Grounded Theory, the inquiry collects data from a large number of participants to generate or develop the theory of process, action, and interactions from the views. Conversely, in the General Inductive Approach, the analysis elicits the primary meaning from the text that is most evident and relevant to the research objectives, i.e., it is more evaluative. This latter method was therefore deemed suitable
for the purposes of the qualitative study (Chapter 6). The description of the findings generated from General Inductive Approaches are based on the most important themes derived from close and repeated reading of the raw data. The purpose of a General Inductive Approach was to develop a model of the underlying theory of experiences to help me understand the reasons for wishing to participate in the postural stability programme and the ideal programme parameters. This model of theory was then included in the consideration of the complex intervention (Chapter 7).

**Studies involved in convergent mixed methods design**

1. *To assess an exercise programme intervention for older adults with Alzheimer’s disease: A proof of concept.*

Evidence from the previous three studies was compiled and synthesised for the design of the intervention. This was the last part of the process of development phase of the complex intervention as described on p. 87.

For the intervention study presented in this thesis (Chapter 7), I had to acknowledge that those living with Alzheimer’s disease are one of the hardest to reach populations. The decision to conduct an exploratory mixed method study prior to the actual feasibility trial was to evaluate several important design considerations including recruitment (Goldberg & Bridges, 1987). Apart from that, the exploratory mixed method study aimed to evaluate the general acceptability, practicality, adherence and safety to the intervention in the first instance.

For this proof of concept study, I employed a convergent mixed method design. The emphasis and weight was on the qualitative data which addressed the acceptability and practicality objectives. The adherence and safety, and adverse event objectives were answered by both the qualitative and quantitative data. Quantitative data were also used to evaluate the success of the recruitment strategies and the secondary objectives of potential health benefits.
As discussed above, in the qualitative aspect of the mixed methods study, I employed the General Inductive Approach (Thomas, 2006). This type of qualitative analysis explores the raw data for significant themes, but without the limitations imposed by methodologies that are more structured (Thomas, 2006). This is useful for more evaluative research which wishes to establish the associations between research objectives and the findings obtained from the raw data (Thomas, 2006).

3.4 Philosophical and methodological considerations

3.4.1 Complex interventions

Complex interventions consist of multiple interacting components, which may act both independently or interdependently for a successful intervention. In health research, the Medical Research Council (MRC) proposed a guideline to evaluate the effectiveness of a new model or theory of intervention. The emphasis is on building up the preliminary works in a systematic way before a full scale trial is conducted (Campbell et al., 2007). The preliminary work is important because it should provide understanding and clarification of the context of the research, the difficulties and the strategies needed to overcome, for instance, the possibility of arriving at invalid outcome measures, the preferences of the delivery of the intervention, the acceptability, the safety of the intervention and the recruitment strategies. The methods that can be used in the preliminary work are flexible and based upon the context of the problems.

The first step towards a complex intervention is to understand the context and to conceptualise the problem(s). This can be done through discussion about the characteristics of the population being studied. Related to the present research in this thesis, the context of the intervention was the needs of older adults with Alzheimer’s disease, a population that potentially has a high risk of falls as discussed in the previous chapter (Chapter 2).

Later, the four core components of complex interventions can be set up: (1) a process of development; (2) feasibility; (3) evaluation; and (4) implementation. The following section will discuss each component (Craig et al., 2008).
The development phase

The aim of the development phase is to collect the appropriate evidence base around the problems that have been conceptualised. This involves three steps: (1) Identifying the evidence base; (2) Identifying / developing theory; and (3) Modelling process and outcomes (Craig et al., 2008).

There are many methods that can be used to identify the evidence. The MRC recommends identifying the evidence through undertaking systematic reviews of existing evidence, which is the first step to complex interventions (Craig et al., 2008). It has been suggested that the highest level of evidence in clinical research is the meta-analysis of randomised trials (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). This involves critical appraisal and critical thinking about the evidence for its validity and usefulness (Rosenberg & Donald, 1995). However, this level of evidence is challenging and requires the publication of homogenous high quality studies.

The second step is to develop the relevant theory for complex interventions (Craig et al., 2008). Here the emphasis is on improving understanding of the theoretical basis of the likely change process (Craig et al., 2008). The suggested strategies are to draw the theory from the existing evidence or by conducting a new study; for example, interviewing ‘stakeholders’. If the decision is to interview ‘stakeholders’, who to interview and what questions to use must be relevant to the ultimate aim of the intervention.

The last step is the modelling process and outcome. It has been recommended to evaluate the planned programme design initially on a small scale, to provide significant information about the structure of the programme before conducting a lengthy and expensive trial (Craig et al., 2008). This step may identify any weakness in the design and areas for refinement of the intervention components and techniques. It also might indicate if a full scale of a trial is warranted.
The feasibility / piloting phase

The second phase is assessing the feasibility of the complex intervention (Craig et al., 2008). In this phase, the information gathered from the first phase is used to develop the optimum intervention and study design (Campbell et al., 2000). The phase of feasibility is to test an intervention for acceptability, compliancy, recruitment and retention rate of participants, and to calculate the sample size for the actual trial (Craig et al., 2008). The main purpose of a feasibility study is to find out the predominant problems that have been identified during the development of the complex intervention. It is an opportunity to determine the consistency of the delivered intervention (Craig et al., 2008). The Medical Research Council recommends the use of a mixed method of study design (Craig et al., 2008). The qualitative part of the study is to estimate the response rates and to explore the barriers to participation (Craig et al., 2008). Video recording can also be used, to provide training and to ensure that the performance of the intervention can be evaluated for consistency (Craig et al., 2008).

The evaluation phase

The third phase is evaluating the complex intervention, namely, assessing the effectiveness, understanding the process, and evaluating cost-effectiveness of the developed intervention (Craig et al., 2008). There is no specific method for the evaluation phase. Even though the Medical Research Council has recommended a randomised clinical trial as the preferred method, other study designs should be considered based on circumstances. Randomised trials enable calculations to estimate the effect and sample size for the main trial (Campbell et al., 2000).

In this phase, one of the important components is the selection of outcome measures. The outcome measure used should not be limited to an evaluation of effectiveness of the intervention but should also encompass accounting relevant to the wider health care system, including economic aspects (Campbell et al., 2000). The collection of data is to assess a range of costs and includes costs for patients, carers, society and also costs for the researcher that challenge the feasibility of the trial.
The implementation phase

The last phase of complex intervention development is to evaluate the implementation of the intervention into practice by dissemination of the findings of the study to relevant stakeholders (Campbell et al., 2000; Faes, Reelick, Esselink, & Rikkert, 2010). The focus is on the percentage of involvement of participants, strength of the intervention, and suitability to broadening of the range of participants to maximise applicability, and also follow up monitoring that is required to establish any long term benefits and to monitor for associated adverse events (Craig et al., 2008; Faes et al., 2010).

3.4.2 Epistemology considerations

The determination of the type of research, to be used to answer the current study’s objectives, was based on what knowledge is; that is, based on the epistemology standpoint or on the pertinent practice or research paradigm (Edwards & Richardson, 2008; Guba & Lincoln, 1994). Practice epistemology can be defined as an individual’s perspective on how the knowledge is generated and used in clinical practice (Edwards & Richardson, 2008). There are three ways knowledge is generated: (1) scientific/positivist (Higgs & Titchen, 1995); (2) critical (Crotty, 1998) and (3) interpretive/constructivist (Guba & Lincoln, 1994). The transition of the standpoint solely depends on the objective, measurable, and predictive knowledge (scientific/positivist) to be integrated with the knowledge generated (critical paradigm) (Craig et al., 2008; Edwards & Richardson, 2008). Whereas context dependent and socially construct knowledge (interpretive paradigm) is to recognise and value the components of each that are essential to optimally inform practice (Craig et al., 2008; Edwards & Richardson, 2008). In approaching person centred dementia care, I believe that the transformation of evidence from research to clinical practise could be optimised through integration of these three difference professional paradigms, that is through pragmatism—mixed method paradigm (Tashakkori & Teddlie, 2010).

As an epistemological assumption, conducting a qualitative study means that I would like to get as close as possible to the participant to better understand their performance in real life (Creswell, 2012); the “researcher becomes an insider” epistemology (Creswell, 2012). I attempted to lessen the distance between myself and those being
researched and became collaborative by spending time in the field with participants as an insider.

I believe that both the qualitative and quantitative study designs have brought valuable knowledge to the production of this thesis. However, the qualitative approach was more influential in informing the proof of concept study (See Chapter 6). As people with Alzheimer’s disease have a long term condition, this study would like to understand the potential intervention that could help to improve postural stability and this could not be determined by a quantitative cause-effects design alone. As mentioned earlier, when both data are integrated, each method will be complementary to each other, thus allowing for a more robust analysis which takes advantage of the differing approaches and data gathered (Tashakkori & Teddlie, 2010).

3.5 Synthesizing data in mixed methods studies

Figure 3.1, p. 80, shows the three points where the synthesising of the data occurred in this thesis, whereas Table 3.1 illustrates the typology of quantitative and qualitative data analysis techniques. There were two stages of data synthesising: The first stage was based on the parallel mixed method design and the second stage based on convergent mixed method design. The data synthesis, however, was not dictated by the direction of the underlying epistemology. The data were generated and integrated from various perspectives for the development phase of the complex intervention (Bazeley, 2009). The definitive purpose of data synthesising in the mixed method approach is to enhance the presentation of the findings.

With respect to the first part of mixed method data synthesis, the findings in each study were integrated. In this current study, integration of the findings was defined based on Woolley (2008) (Woolley, 2008):

> Quantitative and qualitative components can be considered ‘‘integrated’’ to the extent that these components are explicitly related to each other within a single study and in such a way as to be
mutually illuminating, thereby producing findings that are greater than the sum of the parts. (p. 7)

In parallel mixed method design (Chapter 4 to 6), the data of each of the three studies were collected and analysed independently due to the fact that the features and the purpose of each study were not synonymous (Onwuegbuzie, 2000; Tashakkori & Teddlie, 2010). It then involved a process of extracting the findings from the individual research studies and interpreting and presenting them in a collective form (Campbell et al., 2007). The findings from all three studies were integrated to generate a theoretical framework for the design of the exercise programme. This allowed for enhancement and to generate a more meaningful and patient centred design of the last part of the development of the complex intervention.

At the second stage of the data synthesising (convergent mixed method, Chapter 7), a mixed data analysis served as a method of enhancing the presentation of the findings including acceptability, practicality, adherence, safety and recruitment strategy. As mentioned earlier, each study design served its own purpose. In this convergent mixed method study, the emphasis was on the qualitative data which addressed the acceptability and practicality objectives. The adherence, safety and adverse event related objectives were answered by both the qualitative and quantitative data. Quantitative data were also used to evaluate the success of the recruitment strategies and the secondary objectives of potential health benefits. This second stage also served the purpose of testing a theoretical framework; that is, the theory previously developed in the concurrent mixed method study described in Chapters 4 to 6 (Moran-Ellis et al., 2006).

The last part of data synthesising involved theoretical integration from each of the empirical works. The purpose of this integration was to broadly discuss postural stability in older adults with Alzheimer’s disease based on the knowledge produced from each of the studies in this thesis, blending it into a coherent justification (Moran-Ellis et al., 2006). This includes the implications of the development of complex
intervention in research and clinical practise, the limitations and the direction for future research.

Table 3.1 The typology of quantitative and qualitative data analysis techniques

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<tr>
<th>Exploratory data analysis: parallel mixed method</th>
<th>Exploratory data analysis: convergent mixed method</th>
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<tbody>
<tr>
<td>Quantitative data</td>
<td>Quantitative data</td>
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<td>- descriptive statistics</td>
<td>- exploratory data analysis</td>
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<td>- strength of evidence (GRADE)</td>
<td>- correlation</td>
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<td>- narrative (PRISMA)</td>
<td>- ROC curve</td>
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<td>Findings synthesising 1</td>
<td>Findings synthesising 2</td>
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Synthesising 3: Theoretical integration

**Notes.** GRADE, Grading of Recommendations Assessment, Development, and Evaluation; PRISMA, the statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions; ROC, Receiver Operating Characteristic.

3.6 Ethical considerations

Researchers in dementia care need to be aware of the existence of numerous ethical issues (Cubit, 2010; Gauthier, Leuzy, Racine, & Rosa-Neto, 2013; Strech, Mertz, Knüppel, Neitzke, & Schmidhuber, 2013). In particular, obtaining consent from people with Alzheimer’s disease, confidentiality and cultural sensitivity are of concern.

3.6.1 Consent and people with Alzheimer’s disease

As mentioned earlier in Chapter 2 of the thesis, older adults with Alzheimer’s disease have a gradual loss of ability to recognise the significance and commitment of their involvement in any given research due to disease progression (Slaughter, Cole, Jennings, & Reimer, 2007). The possibility of limited competency, to make an informed decision about the purpose of the research and to being committed to taking part, can be misunderstood by both the researcher and the older adults with Alzheimer’s disease (Agnew & Jorgensen, 2012). The concept of competency in Alzheimer’s research was outlined as the ability of older adults with Alzheimer’s disease to be
informed transparently about the procedure of the research (Sachs, 1994). In general, a participant is considered to be competent if they have three fundamental cognitive elements during the consent to research procedure: (1) the ability to comprehend the information; (2) the ability to process the information; and (3) the ability to communicate the decision (S Gauthier et al., 2013; Lai & Karlawish, 2007).

It is believed that gaining information from older adults who have cognitive challenges is perhaps too difficult (Hubbard et al., 2003; Ritchie et al., 2015). But if that belief prevails, then the voice of this potentially vulnerable group will remain unheard. The interview session with older adults with mild to moderate Alzheimer’s disease, may capture indefinite and empty speech due to communication difficulties; for instance, wrong vocabulary or incorrect linguistic reasoning that is hard to understand (Bourgeois, 1991; Hubbard, Cook, Tester, & Downs, 2002). Interviewing this group of the population I foresaw would be difficult and, as a result, I decided to only interview those who had mild to moderate Alzheimer’s disease and thus sufficient capacity to understand and provide consent (Brod, Stewart, & Sands, 1999; Hubbard et al., 2003; Mozley et al., 1999). The interest in people with mild to moderate cognitive impairment, who have been diagnosed with Alzheimer’s disease, in this thesis also related to maximising the number of participants being able to complete the postural stability tests and interventions safely (Steinberg, Leoutsakos, Podewils, & Lyketsos, 2009; Suttanon et al., 2010; Suttanon et al., 2011; Wesson et al., 2013) as described in section 3.7 Sample selection.

In general, the ethical principles in Alzheimer research are: to establish sufficient protection from physical and psychological harm to the vulnerable older adult with Alzheimer’s disease (Gauthier et al., 2013; Hellström, Nolan, Nordenfelt, & Lundh, 2007; Strech et al., 2013), ascertain the awareness of competency during the obtaining of informed consent (Agnew & Jorgensen, 2012; Cubit, 2010; Gauthier et al., 2013), maintaining respect for their autonomy in the decision to take part in the research (Gauthier et al., 2013; Strech et al., 2013), and to ensure non-maleficence (Ryan, Coughlan, & Cronin, 2007).
Respecting the autonomy of potential participants refers to considering their options through discussion and respecting their values and preferences (Cubit, 2010; Strech et al., 2013). Potential participants should be fully informed of the study and any possible risks, and the participation should be entirely voluntary. Every person has the right to withdraw from the research, at any time, without prejudice and this should be clear. In the case where the potential participant experiences a change in psychological wellbeing, for example, anxiety, while acknowledging this alteration might influence the decision to take part in the study, the researcher should obtain the consent in a ‘here and now’ framework rather than purely based on assessed mental capacity (Hellström et al., 2007).

3.6.2 Confidentiality and anonymity

Confidentiality whilst researching dementia care is a crucial issue to consider at many levels, from data collection until the presentation of the findings. Confidentiality is a term defined as akin to privacy (Morse, 1998; Wiles, Crow, Heath, & Charles, 2008). Anonymity is defined as with ‘unknown name’ (Morse, 1998; Wiles et al., 2008). Participants have the right to their information being private and that they should not be recognised by readers of the research (Cheston, Bender, & Byatt, 2000).

Research involving a person who has Alzheimer’s disease requires a multi-disciplinary approach. In this thesis, it has involved academic professional researchers and a physiotherapist as a research assistant. Furthermore, these research findings might be valued by many professionals working in the area of Alzheimer’s disease and thus be shared between interested parties. While some participants with Alzheimer’s might understand the need for information sharing within the research team, some might object to some members of the team knowing about them when they are not directly involved in their care.

Therefore, all data relating to an individual participant were allocated a unique identifier and pseudonyms were used during the presentations of the findings, in particular, the presentation of the qualitative results. Data were stored in a locked cupboard or password protected computer. Access to this information was restricted to
the named researchers. All personal information obtained from this study was kept private and confidential. Data used for publication purposes were kept anonymous.

3.6.3 Cultural sensitivity

It is recognised that the reaction of each individual, who has recently being diagnosed with Alzheimer’s disease, is different. The differences might occur on any level of life experience; for instance, diagnosis might influence life satisfaction, social support, coping or self-efficacy. It could occur on the level of the intrapersonal and the interpersonal, or it could be influenced by the environment or by society values. Cultural sensitivity means valuing each person with respect to factors within their unique identity; for example, literacy, protecting elders and language (Napoles, Chadiha, Eversley, & Moreno-John, 2010).

Participants with Alzheimer’s disease who are recruited at the early stage of the diagnosis, all have fundamental competency with very minimal diminishment of executive function (Gauthier et al., 2013). But at this stage of the disease they are at greater risk of social stigma and discrimination engendered with the very disclosure of their diagnosis of dementia by participating in the research (Gauthier et al., 2013). In this case, to ensure their protection from the harm of this social stigma and the potential for discrimination, the researcher should be fully informed and understand the pathology of Alzheimer’s disease and its relation to the behaviour of the participants. Therefore, an understanding of the nature of the study process involved in the research should be established between the researchers, between the researchers and older adults with Alzheimer’s disease, and between any support person (Gauthier et al., 2013; Strech et al., 2013). Previous literature has suggested that researchers should be aware of the language that they use; for instance, avoid the use of certain phrases, such as “incurable” to prevent the provocation of stigma in older adults with early Alzheimer’s disease (Gauthier et al., 2013).

The presence of significant others during the discussion about the research should help to ensure that the researcher adheres to the principle of non-maleficence and acknowledges the importance of the family or important others in the care of older
adults with Alzheimer’s disease (de Witt, Ploeg, & Black, 2010; Hogan et al., 2008). But the significant others should not be there to abuse trust (Bartlett & Martin, 2002; Gilteard & Higgs, 2016; Hughes & Baldwin, 2006). Previous researchers have noted that the significant others may sometimes have a vested interest in convincing the older adults with Alzheimer’s disease to participate in the research, especially in situations where carers see themselves as benefiting (Bjørneby et al., 2004). The contribution of support persons is not only viewed as a proxy to the participant with mild to moderate Alzheimer’s disease, but the support person can also viewed as an important person enabling successful caregiving (Maas et al., 2004).

3.7 Sample selection

The findings from all four studies highlight which components of postural stability should be emphasised in research and clinical practice, the outcome measures to be used to evaluate possible changes in postural stability performance, how the interventions work and how to find the potential barriers to change engagement for older adults with Alzheimer’s disease in the use of an intervention to improve postural stability. Exploration of their perspectives and preferences also empowers and informs decision making, prioritising what is important in the intervention delivery specifically for older adults with Alzheimer’s disease (Thornquist, 2001). Therefore, purposive sampling was chosen throughout all of the studies which are reported in chapters 5, 6 and 7 excluding the literature review (Onwueguzie & Collins, 2007; Teddlie & Yu, 2007; Tongco, 2007). For the production of this thesis, purposive sampling occurred at every point of data collection.

Informants are those considered to be able to give information that is specifically relevant to the topic under investigation. In this context of study, informants were older adults with mild to moderate Alzheimer’s disease and their support person. To receive relevant information from the informants purposive sampling was undertaken. Purposive sampling is defined as “techniques” primarily used in both quantitative and qualitative studies and may be defined as selecting units (e.g., individuals, groups of individuals, institutions) based on specific purposes associated with answering a research study’s questions” (Teddle and Yu (2007), p. 77) (Tashakkori & Teddle,
The purposive sampling technique is also widely used to increase transferability (Collins, Onwuegbuzie, & Jiao, 2006; Miles & Huberman, 1994). For instance, in this current study, the specific purpose was to explore perceptions among older adults with mild to moderate Alzheimer’s disease who reside in the community. These individuals were purposely selected with the intent of maximising variation in these specific variables rather than randomly selected from the whole population that includes those who are living in long term care.

Moreover, I purposely sampled older adults with mild to moderate cognitive impairment and excluded those who had severe cognitive impairment with Alzheimer’s disease. I was interested in exploring this specific cohort because this population has usually reserved sufficient components of cognitive function and a certain level of physical function to ensure that they are safe to complete the postural stability tests and the interventions (Steinberg et al., 2009; Suttanon et al., 2010; Suttanon et al., 2011; Wesson et al., 2013). Theoretically, older adults with mild to moderate Alzheimer’s disease should be able to understand and interact in the meaningful way while participating in each study (Hubbard et al., 2003; Zhua et al., 2015). In Dunedin, it would appear that different healthcare professionals use different systems to diagnose Alzheimer’s disease. In Chapter 2 the differences in diagnostic criteria were presented. I foresaw this as a major challenge to the recruitment of participants. Given the lack of specificity for the studies presented in this thesis, I included all people who were diagnosed with Alzheimer’s disease by their local healthcare professional, irrespective of diagnostic system used.

In all the stages of the quantitative and qualitative data collection in this thesis, the support person involvement could minimise the bias in reporting. The voice of the support person, who is a central to the care-recipient, may have an impact for them on the caregiving experience (Quinn, Clare, & Woods, 2009). The support person could provide more insightful information particularly when the older adult with mild to moderate Alzheimer’s disease might have difficulty recalling experiences. Previous research has found that participation of the support person in the intervention can also improve in their experience of caregiving (Maas et al., 2004). Therefore, the inclusion
of the support person in this thesis might enhance of the importance of an intervention which might minimise the occurrence of falls by their care-recipient. Other than that, it provides the opportunity for education around the intervention for the support person and gives a platform for peer support (Parker, Mills, & Abbey, 2008).

3.8 Summary

In this chapter I have outlined the methodology and the framework underpinning this thesis. In particular I have highlighted the importance and value of mixed methods research in the development of complex interventions and I have discussed the ethical issues pertinent to research on older adults with Alzheimer’s disease. The next chapter covers the first study which achieves the first aim of this thesis: to identify the current evidence for the status of postural stability and the associated factors which influence postural instability in older adults with Alzheimer’s disease.
CHAPTER 4: Study 1

A systematic review

4.1 Introduction

This chapter answers the first objective of this thesis, which was to identify the current evidence of postural instability in older adults with Alzheimer’s disease and any associated factors which influence postural stability in this population. This systematic review was published in Physical Therapy in 2017. The review’s questions were:

1. Do older adults with mild to moderate Alzheimer’s disease have reduced postural stability compared with a control group of healthy peers?

2. What specific factors contribute to, or impact on, postural instability in people with mild to moderate Alzheimer’s disease?

4.2 Methods

4.2.1 Data sources and searches

To identify the requisite articles, a systematic search of the Medline, EMBASE, AMED, Pubmed, Scopus and Web of Science databases for publications from 1984 onwards, limited to articles in the English language, was undertaken. Grey literature was excluded. The search period was determined by the publication of the classification for clinical diagnosis of Alzheimer’s disease in 1984 by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer Disease and Related Disorders Association (NINCDS-ADRDA) (McKhann et al., 1984; McKhann et al., 2011). The search was carried out on the 2nd June 2015 using the main keywords of ‘postural stability’ and ‘Alzheimer’s disease’. The Boolean operators ‘AND’ and ‘OR’ were used to combine the keywords. The titles and abstracts of the identified papers were screened by two independent reviewers, I and MK to select relevant
articles. The full-texts of these articles were obtained and reviewed by I and MK against the predetermined inclusion criteria. Disagreements were discussed and resolved by consensus with a third reviewer (LH).

4.2.2 Study selection

Design

Study designs included in the review were observational study designs (prospective cohort, case-control, longitudinal and cross-sectional study designs) that included people with Alzheimer’s disease and, as controls, healthy peers without Alzheimer’s disease.

Participants

Participants had to be diagnosed with Alzheimer’s disease, confirmed by medical specialists based on NINCDS-ADRDA criteria, (McKhann et al., 1984; McKhann et al., 2011) or with dementia of Alzheimer’s disease type confirmed by the Diagnostic and Statistical manual for Mental disorder (DSM), (American Psychiatric Association, 1994) or by the International Classification of Disease and Related Health Problems 10th Revision (ICD-10) (World Health Organization, 2004). Further criteria included participants being aged 40 years and above, and the presence of mild to moderate cognitive impairment as this population are likely to benefit the most from any physical intervention (Heyn, Abreu, & Ottenbacher, 2004).

The level of cognitive impairment score of the participants in the selected studies had to be assessed with a validated global cognitive function test, for instance, the MMSE, (Folstein et al., 1975) or the Clinical Dementia Rating scale (Berg et al., 1982; Morris, 1997). The MMSE scores range between 0-30. Normal cognition is classified as a score between 23 and 30, and mild, moderate and severe cognitive impairment classified as scores of 18-23, 10-17 and < 10 respectively (Folstein et al., 1975). Whereas, the classification for Clinical Dementia Rating is 0 (normal), 0.5 (questionable cognitive impairment), 1 (mild), 2 (moderate) and 3 (severe) to indicate the level of cognitive function (Morris, 1997).
Articles were included in the review if more than 80% of the participants were diagnosed with Alzheimer’s disease and presenting with mild to moderate cognitive impairment or there were separate data based on level of cognitive impairment and the comparison group of controls were cognitively intact, healthy peers.

**Outcome measures**

Studies had to use validated measures of postural stability. These included: 1) A measure of static, dynamic or functional performance of postural stability, either laboratory (such as the computerised dynamic posturography platform (EquiTest) or force platform AccuGait) or clinical (such as the Berg Balance Scale, (Berg, Wood-Dauphine, Williams, & Gayton, 1989) or Step Test (Hill et al., 1996)) measures; the postural stability should be measured in conditions which ensure vision, somatosensory and vestibular senses are available; and 2) An analysis of factors contributing to, or impacting on, postural stability, for example, a measure of muscle power, or of the somatosensory, visual or vestibular systems. For the purposes of this systematic review, static postural stability was defined as the ability to maintain the body within the limits of stability during quiet standing (Woollacott & Shumway-Cook, 1996). Dynamic postural stability was defined as the ability to maintain and/or regain stability after an external threat or change in the platform sufficient to challenge the balance occurred (Woollacott & Shumway-Cook, 1996). Functional performance of postural stability was defined as a rate of performance in a set of tasks to evaluate the ability to maintain stability in a particular posture or activity (Horak, 1997).

**Data extraction and quality assessment**

Data were extracted from the included studies by me independently and cross-checked by MK to a standardised extraction form. Information and data about the study method (design, participant sample data: sample size, age, sex, cognitive function, diagnosis criteria, duration of illness, setting, country), details of postural stability measures (postural stability testing, protocol, measurement of postural stability and finding of the studies) and details of factors contributing to postural instability were extracted.
The quality of the included studies was assessed using a modified checklist by Downs and Black (1998) (Downs & Black, 1998). The Downs and Black checklist was designed to accommodate various study methodologies. When items were not relevant due to methodology, they were not included. The inter-rater reliability of the modified Downs and Black, which was used in our study, is moderate to good (Intraclass correlation, ICC = 0.73; 95% CI 0.47, 0.88) (Hootman, Driban, Sitler, Harris, & Cattano, 2011). For our review, out of 28 items, 14 items were used to represent four categories: reporting, external validity, internal validity (bias) and internal validity (confounding). Items number 4, 8-9, 13-15, 17, 19, 21, 23-24 and 26 were not used because they are not relevant for observational study designs (Mani, Milosavljevic, & Sullivan, 2010) and relate more specifically to randomised trial (e.g., inclusion of an independent control group). Each item was assessed by two independent raters, myself and MK, with a third rater (MP) resolving any disagreements for each study. A study was considered ‘high’ quality if the combined item score was greater than 75%, ‘moderate’ if it scored 50-74% and ‘low’ quality if it scored less than 50% (Mani et al., 2010). The score from this quality assessment was used to justify the risk of bias and the strength of evidence to address the research questions of this systematic review. Absent information was marked ‘unclear’.

**Data synthesis and analysis**

The data were pooled in respect to postural stability performance and contributing factors of postural instability in people with mild to moderate Alzheimer’s disease. Heterogeneity of the data was calculated to evaluate the possibility of conducting a meta-analysis. The $I^2$ value was estimated to be between 75-100%, i.e., that of considerable heterogeneity of the data (Higgins & Thompson, 2002). This is likely due to clinical heterogeneity with differences in participants recruited, outcome measures used, or to methodological heterogeneity due to differences in study design evident between studies. Therefore, the data were analysed using qualitative synthesis and reported in a narrative approach based on the PRISMA guidelines (Liberati et al., 2009). The strength of evidence was guided by Grading of Recommendations Assessment, Development, and Evaluation (GRADE) and indicated as (1) ‘strong evidence’, with at least of one high quality study and supported by 3 moderate quality
observational studies with a high consistency of findings; (2) ‘moderate evidence’, with
≥4 moderate quality observational studies with a high consistency of findings; or (3)
‘weak evidence’, with ≤3 moderate or low quality observational studies with
inconsistency of findings (Guyatt et al., 2011).

4.3 Results
4.3.1 Results of study search
The initial computerised search returned 1394 articles. Seven additional records were
identified through other sources, such as Google Scholar. After the first screening of
titles and abstracts, 67 articles were retrieved for full text evaluation. A final total of 18
studies met the inclusion criteria and were included in the review. A hand search of the
lists of references did not yield any additional studies for inclusion. See Figure 4.1 for
details of the included and excluded studies. The list of excluded studies is presented in
Appendix D.
4.3.2 Study design

A summary of the included studies is presented in Table 4.1. Eighteen cross-sectional studies investigated and compared postural stability in people with mild to moderate Alzheimer’s disease with cognitively intact and healthy peers (Allan, Ballard, Burn, & Kenny, 2005; Chong et al., 1999; Chong et al., 1999a; de Andrade et al., 2014; Dickin
& Rose, 2004; Elble & Leffler, 2000; Franssen et al., 1999; Gago et al., 2014; Gras et al., 2015; Kato-Narita et al., 2011; Kido et al., 2010; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Nakamura et al., 1997; Pettersson et al., 2002; Pettersson et al., 2005; Suttanon et al., 2012a).
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants</th>
<th>Control group</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allan et al. (2005)</td>
<td>CS</td>
<td>n = 40</td>
<td>n = 42</td>
<td>UK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>age, yr = 78.6 (5.6)</td>
<td>Age, yr = 75.9 (6.7)</td>
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<td></td>
<td></td>
<td>F=22</td>
<td>F = 20</td>
<td></td>
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<td></td>
<td></td>
<td>CAMCOG = 59.0 (14.5)</td>
<td>CAMCOG = 94.0 (4.7)</td>
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<tr>
<td></td>
<td></td>
<td>Diagnosis = NINCDS-ADRDA</td>
<td>Recruitment = Community</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Duration of illness = 3yr (2-67 months)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Recruitment = Cases in neurology, geriatric psychiatry and geriatric medical services</td>
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</tr>
<tr>
<td>de Andrade et al.</td>
<td>CS</td>
<td>n = 12</td>
<td>n = 13</td>
<td>Brazil</td>
</tr>
<tr>
<td>(2014)</td>
<td></td>
<td>Age, yr = 72.2 (7.3)</td>
<td>Age, yr = 65.8 (4.5)</td>
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<td></td>
<td></td>
<td>F = 9</td>
<td>F = 7</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>MMSE = 20.7 (4.0)</td>
<td>MMSE = 27.6 (2.5)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Diagnosis = DSM-IV/ ICD-10</td>
<td>Recruitment = Participants in specific physical activity programme</td>
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<tr>
<td></td>
<td></td>
<td>Duration of illness = Not reported</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recruitment = Participants in specific physical activity programme</td>
<td></td>
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</tr>
<tr>
<td>Chong et al. (1999a)</td>
<td>CS</td>
<td>n = 11</td>
<td>n = 12</td>
<td>UK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age, yr = 72 (10)</td>
<td>Age, yr = 62 (5)</td>
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<td></td>
<td></td>
<td>F = 6</td>
<td>F = 5</td>
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<tr>
<td></td>
<td></td>
<td>MMSE = 19 (5)</td>
<td>MMSE = Unable to determine</td>
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<tr>
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<td></td>
<td>Diagnosis probable AD = NINCDS-ADRDA</td>
<td>Recruitment = Unable to determine</td>
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<tr>
<td></td>
<td></td>
<td>Duration of illness = Not reported</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Recruitment = Unable to determine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chong et al. (1999)</td>
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<td>n = 11</td>
<td>n = 17</td>
<td>UK</td>
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<tr>
<td></td>
<td></td>
<td>Age, yr = 73 (10)</td>
<td>Age, yr = 65 (6)</td>
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<td></td>
<td></td>
<td>F = 5</td>
<td>F = 8</td>
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<tr>
<td></td>
<td></td>
<td>MMSE = 19 (6)</td>
<td>MMSE = Unable to determine</td>
<td></td>
</tr>
<tr>
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<td>Website</td>
<td>n</td>
<td>Age, yr</td>
<td>F</td>
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<td>-----------------------------</td>
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<tr>
<td>Dickin and Rose (2004)</td>
<td>CS</td>
<td>6</td>
<td>82.0</td>
<td>3.6</td>
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<td></td>
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<td>6</td>
<td>79.3</td>
<td>5.5</td>
</tr>
<tr>
<td>Elble and Leffler (2000)</td>
<td>CS</td>
<td>11</td>
<td>76.3</td>
<td>4.9</td>
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<tr>
<td>Franssen et al. (1999)</td>
<td>CS</td>
<td>101</td>
<td>73.3</td>
<td>7.7</td>
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<td></td>
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<tr>
<td></td>
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<td>195</td>
<td>68.1</td>
<td>9.6</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Male/Female</td>
<td>Age, Mean (SD)</td>
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<td>---------------</td>
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<td>----------------</td>
</tr>
<tr>
<td>Gago et al. (2014)</td>
<td>Portugal</td>
<td>16</td>
<td>6</td>
<td>72.3 (7.1)</td>
</tr>
<tr>
<td>Gras et al. (2015)</td>
<td>US</td>
<td>13</td>
<td>3</td>
<td>72.6 (4.6)</td>
</tr>
</tbody>
</table>

**Gago et al. (2014)**
- **CS**
- ADNF: n = 9, F = 7
  - Age, yr = 73.6 (8.7)
  - CDR = 1 (range 0.5 - 2)
  - Duration of illness, yr = 2.3 (1.9)

**Gras et al. (2015)**
- **CS**
  - n = 13
  - F = 3
  - Age, yr = 72.9 (4.7)
  - MMSE = 24.8 (2.6)
  - CDR = 0.5
  - Diagnosis = A board certified neurologist specialising in AD
  - Duration of illness = Not reported

**Diagnosis**
- NINCDS-ADRDA

**Duration of illness**
- Not reported
<table>
<thead>
<tr>
<th>Study</th>
<th>Gender</th>
<th>Age, yr</th>
<th>MMSE</th>
<th>Diagnosis</th>
<th>Duration of illness</th>
<th>Recruitment</th>
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<td>Kato-Narita et al. (2011)</td>
<td>n = 48</td>
<td>77 (6.3)</td>
<td>16.2</td>
<td>NINCDS-ADRDA</td>
<td>Not reported</td>
<td>outpatient service at a university hospital</td>
</tr>
<tr>
<td>Kido et al. (2010)</td>
<td>n = 21</td>
<td>79 (6)</td>
<td>16 (4)</td>
<td>NINCDS-ADRDA</td>
<td>Not reported</td>
<td>Medical checkup programme, Ehime University Hospital</td>
</tr>
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<td>n = 15</td>
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<td>Not available</td>
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</tr>
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<td>79.7 (5.1)</td>
<td>21 (2)</td>
<td>NINCDS-ADRDA &amp; DSM-IV</td>
<td>&gt; 2 yr</td>
<td>Community</td>
</tr>
<tr>
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<td>F</td>
<td>Age, yr</td>
<td>MMSE</td>
<td>Diagnosis</td>
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<tr>
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<td>150</td>
<td>83 (5.8)</td>
<td>19.3 (4.4)</td>
<td>NINCDS-ADRDA &amp; DSM-IV</td>
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<tr>
<td>Nakamura et al. (1997)</td>
<td>CS</td>
<td>15</td>
<td>10</td>
<td>75.9 (3.6)</td>
<td>18.6 (1.7)</td>
<td>NINCDS-ADRDA &amp; DSM-III</td>
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<tr>
<td>Pettersson et al. (2005)</td>
<td>CS</td>
<td>22</td>
<td>10</td>
<td>77.5 (4.0)</td>
<td>11.4 (2.6)</td>
<td>NINCDS-ADRDA &amp; DSM-III</td>
</tr>
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</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>n</td>
<td>F</td>
<td>Age, yr</td>
<td>MMSE</td>
<td>Diagnosis</td>
</tr>
<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td>Pettersson et al. (2002)</td>
<td>Sweden</td>
<td>17</td>
<td>8</td>
<td>68 (9.9)</td>
<td>24 (range 17 - 30)</td>
<td>DSM-IV</td>
</tr>
<tr>
<td>Suttanon et al. (2012a)</td>
<td>Australia</td>
<td>25</td>
<td>16</td>
<td>80.4 (21.1)</td>
<td>21.1</td>
<td>NINCDS-ADRDA</td>
</tr>
</tbody>
</table>

**Notes.** AD, Alzheimer’s Disease; ADAS-cog, Alzheimer’s Disease Assessment Scale-Cognitive subscale; ADF, Alzheimer’s disease faller; ADNF, Alzheimer’s disease non-faller; CAMCOG, Cambridge Cognition Examination; CDR, Washington University Clinical Dementia Rating; CS, Cross-sectional study; DSMIII, Diagnostic and Statistical Manual for mental disorder version III; DSM IV, Diagnostic and Statistical Manual for mental disorder version IV; GDS, Global Deterioration Scale; ICD-10, International Classification of Disease and Related Health Problems 10th Revision; LS, longitudinal study; MCI, mild cognitive impairment; MMSE, Mini-Mental State Examination; NINCDS-ADRDA, National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association. All values are mean (standard deviation) or as otherwise indicated.
4.3.3 Setting

The trials were conducted in well-developed countries including: United Kingdom, (Allan et al., 2005; Chong et al., 1999; Chong et al., 1999a) Brazil, (de Andrade et al., 2014) United States, (Dickin & Rose, 2004; Elble & Leffler, 2000; Franssen et al., 1999; Gras et al., 2015) Portugal, (Gago et al., 2014) Japan, (Kato-Narita et al., 2011; Kido et al., 2010; Nakamura et al., 1997) Italy, (Leandri et al., 2009) France, (Manckoundia et al., 2006; Mignardot et al., 2014) Australia, (Suttanon et al., 2012a) and Sweden (Pettersson et al., 2002; Pettersson et al., 2005). Eleven studies were conducted in a laboratory setting of a university or a hospital (Allan et al., 2005; Elble & Leffler, 2000; Franssen et al., 1999; Gago et al., 2014; Gras et al., 2015; Kato-Narita et al., 2011; Kido et al., 2010; Mignardot et al., 2014; Nakamura et al., 1997; Pettersson et al., 2002; Pettersson et al., 2005). Two studies were conducted in a long term care facility and a community setting (Dickin & Rose, 2004; Manckoundia et al., 2006). One study recruited participants from a specific physical activity programme, (de Andrade et al., 2014) one study from a memory clinic and the community, (Suttanon et al., 2012a) and three studies did not specify (Chong et al., 1999; Chong et al., 1999a; Leandri et al., 2009).

4.3.4 Participants

Sample sizes of individual studies ranged from 22 to 471. The distribution of female participants with mild to moderate Alzheimer’s disease to the control healthy peers group was 318/512 and 503/986 respectively. However one study did not report sex distribution (Franssen et al., 1999). The mean (SD) age of participants with mild to moderate Alzheimer’s disease across all studies was 76 (4) years, with the range being from 68 to 83 years old. In the healthy peers control group, the mean (SD) age was 72 (6) years and ranged from 57 to 82 years.

4.3.5 Diagnosis

The diagnosis of Alzheimer’s disease was based on NINCDS-ADRDA criteria, (Allan et al., 2005; Chong et al., 1999; Chong et al., 1999a; Dickin & Rose, 2004; Elble & Leffler, 2000; Franssen et al., 1999; Gago et al., 2014; Kato-Narita et al., 2011; Kido et al., 2010; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014;
Nakamura et al., 1997; Pettersson et al., 2002; Suttanon et al., 2012a) DSM-IV, (de Andrade et al., 2014; Gago et al., 2014; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Pettersson et al., 2005) DSM-III, (Nakamura et al., 1997; Pettersson et al., 2002) and ICD-10 (de Andrade et al., 2014). In one study, diagnosis was determined by clinical assessments and subsequently confirmed by a medical specialist (Gras et al., 2015).

4.3.6 Cognitive function

Cognitive function was tested with the MMSE in 12 studies (Chong et al., 1999; Chong et al., 1999a; de Andrade et al., 2014; Dickin & Rose, 2004; Franssen et al., 1999; Kato-Narita et al., 2011; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Pettersson et al., 2002; Pettersson et al., 2005; Suttanon et al., 2012a), the Clinical Dementia Rating in 2 (Gras et al., 2015; Nakamura et al., 1997), the Cambridge Cognition Examination in 1 (Allan et al., 2005), the Hesegawa Dementia Scale in 1 (Kido et al., 2010), the Alzheimer's Disease Assessment Scale-Cognitive subscale in 1 (Leandri et al., 2009) and the Global Deterioration Scale (GDS) in 1 (Franssen et al., 1999). All studies classified people with Alzheimer’s disease as having mild to moderate cognitive impairment with MMSE range of 10-30, Cambridge Cognition Examination 34.5-73.5, Clinical Dementia Rating 0.5-2 and Clinical Dementia Rating 4. However, the study by Leandri et al. (2009) used the MMSE and Alzheimer's Disease Assessment Scale-Cognitive subscale to classify mild to moderate cognitive impairment but did not state their cut off scores (Leandri et al., 2009).

For the control healthy peers, fourteen studies reported the score of ‘normal’ from cognitive function tests (Allan et al., 2005; de Andrade et al., 2014; Dickin & Rose, 2004; Elble & Leffler, 2000; Franssen et al., 1999; Gras et al., 2015; Kato-Narita et al., 2011; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Nakamura et al., 1997; Pettersson et al., 2002; Pettersson et al., 2005; Suttanon et al., 2012a). The remaining studies simply stated that cognitive function of healthy peers control group was ‘normal’.
### 4.3.7 Measurement of postural stability

This review includes studies that used both laboratory. Table 4.2 and clinical outcome measures of postural stability Table 4.3. Ten different laboratory-based measures were used to evaluate postural stability including: computerised dynamic posturography platform (EquiTest) (Chong et al., 1999), Force platform AccuGait (de Andrade et al., 2014), Biorescue (Mignardot et al., 2014), Smart Balance Master (Dickin & Rose, 2004), computerised motion analysis system (Elble & Leffler, 2000), triaxial accelerometers and gyroscopes (Gago et al., 2014), stabilometry (Leandri et al., 2009), Force platform (Techno concept) (Manckoundia et al., 2006), Gravicoder (Nakamura et al., 1997), and the NeuroCom Balance Master (Suttanon et al., 2012a). The postural stability measurement variables used were: centre of pressure based variables (de Andrade et al., 2014; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014), Root Mean Square (Nakamura et al., 1997), centre of mass based variables (Chong et al., 1999; Elble & Leffler, 2000; Gago et al., 2014), sway velocity (Suttanon et al., 2012a), limit of stability variables (Suttanon et al., 2012a), centre of gravity and percent equilibrium (Dickin & Rose, 2004).

The clinically-based outcome measures were: single leg stance (Kido et al., 2010), step test (Suttanon et al., 2012a), functional reach test (Suttanon et al., 2012a), Berg Balance Scale (Kato-Narita et al., 2011; Pettersson et al., 2002; Pettersson et al., 2005), Performance-Oriented Assessment of Mobility (Allan et al., 2005), Timed Up and Go test (Gras et al., 2015; Pettersson et al., 2002; Pettersson et al., 2005; Suttanon et al., 2012a), figure of eight test (Pettersson et al., 2002) and parametric rating scale for equilibrium and limb coordination (Franssen et al., 1999). The variables used for clinical outcome measures of postural stability were: time to complete the task(s), the limits of stability measured as a distance (cm), the number of steps taken in a set time, classification (mild, moderate, severe) or based on score of postural stability performance or based on the score for a set of functional postural stability performances for equilibrium and limb coordination, and the Berg Balance Scale.

The postural stability was tested in: quiet single (Kido et al., 2010) or double leg stance (Chong et al., 1999; de Andrade et al., 2014; Dickin & Rose, 2004; Elble & Leffler,
2000; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Suttanon et al., 2012a), tandem (Gras et al., 2015) or Romberg (Gago et al., 2014; Nakamura et al., 1997) stance on a normal surface with EO (Chong et al., 1999; de Andrade et al., 2014; Dickin & Rose, 2004; Elble & Leffler, 2000; Gago et al., 2014; Gras et al., 2015; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Suttanon et al., 2012a), normal surface with eyes closed (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014; Leandri et al., 2009; Mignardot et al., 2014; Suttanon et al., 2012a), combination of availability of senses (vestibular, vision, somatosensory) (Chong et al., 1999; Dickin & Rose, 2004; Suttanon et al., 2012a) and different platform conditions (incongruent surface, toes up rotations, rise to toes, backward or forward inclination and soft surface) (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014; Suttanon et al., 2012a). Functional postural stability performance was tested with a variety of tasks, for instance, sit to stand, turning 360°, and picking an object up from the floor (Allan et al., 2005; Franssen et al., 1999; Kato-Narita et al., 2011; Pettersson et al., 2002; Pettersson et al., 2005).
<table>
<thead>
<tr>
<th>Study</th>
<th>Postural stability testing</th>
<th>Task / protocol/ instruction</th>
<th>Measurement of postural stability</th>
<th>Results</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>de Andrade et al. (2014)</td>
<td>Force platform AMTI model AccuGait</td>
<td>Upright stance, arms alongside the body and gaze on the target. Sampling rate = 100Hz Trial length = 40s No. of trials = 3</td>
<td>Static postural stability: COP position-based 1. COP displacement (mm) 2. COP area (mm²)</td>
<td>No significant difference (COP displacement p = 0.98 and COP area p = 0.96).</td>
<td>61</td>
</tr>
<tr>
<td>Chong et al. (1999)</td>
<td>Computerised dynamic posturography platform (EquiTest)</td>
<td>Participants’ ability to maintain in-place postural stability under combination of normal, absent, and/or incongruent visual, vestibular, and somatosensory and support surface conditions was tested. Upright stance x 6 conditions (C1: EO_NS; C2: EC_NS; C3: IV_NS; C4: EO_IS; C5: EC_IS; C6: IV_IS). Sampling rate = 50Hz Trial length = 20s No. of trials = C1-C2 2Ts, C3-C6 3Ts</td>
<td>The calculated ankle and hip angles from the trigonometric conversions were used to derive the participant’s AP COM. Static (C1) and dynamic (C4) postural stability: 1. PTP AP COM sway on successful trials 2. PTP AP COM sway amplitude</td>
<td>No significant difference (p &gt; 0.05) in CI and C4.</td>
<td>61</td>
</tr>
<tr>
<td>Dickin and Rose (2004)</td>
<td>Smart Balance Master</td>
<td>Participants’ ability to maintain in-place postural stability under combination of normal, absent, and/or incongruent visual, vestibular, and somatosensory and support surface conditions was tested. Upright stance x 6 conditions</td>
<td>Static (C1) and dynamic (C4) postural stability: 1. COG movement velocity 2. Percent Equilibrium</td>
<td>No significant difference COG movement velocity (p &gt; 0.05) in CI and C4. Significant difference for percent equilibrium (p = 0.07) in CI and C4.</td>
<td>72</td>
</tr>
<tr>
<td>Study</td>
<td>Equipment/Methodology</td>
<td>Instructions/Conditions</td>
<td>Results</td>
<td></td>
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</tr>
<tr>
<td>Elble and Leffler (2000)</td>
<td>Computerised Motion Analysis system</td>
<td>The participants were instructed to push or pull the force cursor into the target box as quickly and as accurately as possible while maintaining stable erect stance without leaning into or away from the bar. Stable erect stand (elbow flex at 30° and Sh. Flex at 45° in sagittal plane) x 4 conditions (75% push, 50% push, 75% pull &amp; 50% pull). No. of trials = 4</td>
<td>No significant difference (p &gt; 0.15).</td>
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</tr>
</tbody>
</table>
| Gago et al. (2014)            | Triaxial accelerometers and gyroscopes                                               | Romberg quite stance (medial aspect of the feet touching together) x 2 conditions (EO & EC) x 3 platform (flat surface, backward and forward inclination) | Static and dynamic postural stability: COM position-based  
1. Total COM displacement (cm)  
2. Maximum COM displacement (cm)-safety limit  
3. AP COM displacement (cm)  
4. ML COM displacement (cm)  
COM velocity-based | No significant difference in all conditions (p > 0.05).                              |
<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Conditions</th>
<th>Parameters</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leandri et al. (2009)</td>
<td>Stabilometry</td>
<td>Upright stance x 2 conditions (EO &amp; EC)</td>
<td>Sampling rate = 100Hz, Trial length = NA, No. of trials = NA</td>
<td>Significant difference in all conditions and directions (p &lt; 0.05).</td>
</tr>
<tr>
<td>Manckoundia et al. (2006)</td>
<td>Force platform (Techno Concept)</td>
<td>Upright stance with EO and looking straight at a 13 circle on the wall 2 meters away for approximately 13 seconds.</td>
<td>Static postural stability: COP position-based 1. COP displacement (mm), 2. COP area (mm²)</td>
<td>Significant difference in all directions (p &lt; 0.05).</td>
</tr>
<tr>
<td>Mignardot et al. (2014)</td>
<td>Force platform (BioRescue)</td>
<td>Upright stance x 2 conditions (EO &amp; EC)</td>
<td>Sampling rate = 5Hz, Trial length = 51.2s, No. of trials = 2</td>
<td>Significant difference in all conditions and directions (p &lt; 0.05).</td>
</tr>
<tr>
<td>Nakamura et al. (1997)</td>
<td>Gravicorder</td>
<td>Romberg stance for 60 seconds, Sampling rate = 20Hz, Trial length = 60s, No. of trials = N/A</td>
<td>Static postural stability: RMS</td>
<td>Significant differences (p &lt; 0.05).</td>
</tr>
<tr>
<td>Suttanon et al. Neurocom Balance Master (2012a)</td>
<td>1. Upright stance x 4 conditions (EO, EC, EOF &amp; ECF) (mCTSIB)</td>
<td>2. Upright stance x 8 directions</td>
<td>3. Sit to stand sway</td>
<td>Variables;</td>
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<tr>
<td></td>
<td>Static postural stability:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1. Sway velocity, (°/s)</td>
<td>Dynamic postural stability:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2. LOS_MVL, (°/s)</td>
<td>3. LOS_MXE, % LOS boundary</td>
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<td></td>
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<td></td>
<td>4. LOS_DCL, %</td>
<td></td>
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<td></td>
<td>Functional postural stability:</td>
<td>5. Sit to stand sway velocity (°/s)</td>
<td></td>
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</tr>
</tbody>
</table>

Notes. AAMV, Average Absolute Maximal Velocity; AP, anterior-posterior; EO, eyes open; EO_NS, condition 1: eyes open with a stable support surface and stable visual around; C2: EC_NS, eyes closed with a stable support surface; C3: IV_NS, eyes open with a stable support surface and sway-referenced visual surround; C4: EO_IS, eyes open with sway-referenced support surface and a stable visual face; C5: EC_IS, eyes closed with a sway-referenced support surface; C6: IV_IS, eyes open with both the support surface and the visual surround sway-referenced support surface; COP, centre-of-pressure; DCL, directional control; EC, eyes closed; EO, eye open; EOF, eye open on foam surface; ECF, eye closed on foam surface; LOS, Limit of stability; mCTSIB, modified Clinical Test of Sensory Interaction on Balance; COM, centre of mass; ML, medio-lateral; MVL, movement velocity; MXE, maximum excursion; PTP AP COM, peak-to-peak centre of mass in anterior-posterior; Q, quality; RMS, root mean square; Ts, trials; IS, incongruent surface; IV, incongruent visual.
<table>
<thead>
<tr>
<th>Study</th>
<th>Postural stability testing</th>
<th>Task</th>
<th>Measurement of postural stability</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allan et al. (2005)</td>
<td>POMA</td>
<td>Functional performance: 13 balance items were rated from 0-2,</td>
<td>Scale:</td>
<td>AD had worse POMA scores than healthy peers (p = 0.001).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with a maximum score of 26. 9 gait items were rated from 0-1 with a</td>
<td>1. mild</td>
<td>Sub-analysis found no significant differences between mild AD and control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum of 9. The scores were classified as mild, moderate and severe</td>
<td>2. moderate</td>
<td>healthy peers (p &gt; 0.05).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>impairments.</td>
<td>3. severe</td>
<td></td>
</tr>
<tr>
<td>Franssen et al. (1999)</td>
<td>Parametric rating 5-point scale for equilibrium and limb coordination</td>
<td>Functional performance: There were 5 tests: 1. SLS 10s (Both legs)</td>
<td>Score:</td>
<td>Significantly decreased performance on all 5 clinical tests (p &lt; 0.05).</td>
</tr>
<tr>
<td></td>
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<td>2. TW 10-30s</td>
<td>Equilibrium &amp; limb coordination. The higher the score, the better the</td>
<td></td>
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<td></td>
<td>3. FT 5s (Both feet)</td>
<td>postural stability.</td>
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<td>4. Bilateral PS 5s (both hands)</td>
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<td>5. FTH 5s (both hands)</td>
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<tr>
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<td>An individual performance of each test was graded on a 5-point rating</td>
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<tr>
<td></td>
<td></td>
<td>scale. All tests were performed with EO. 3Ts and the highest score was</td>
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<tr>
<td></td>
<td></td>
<td>counted for total score. For the bilateral test, the higher of the two</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>lateral scores obtained was used for analysis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Measure(s)</td>
<td>Static Postural Stability</td>
<td>Functional Performance</td>
<td>Significant Difference</td>
</tr>
<tr>
<td>-------------------------------</td>
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<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Gras et al. (2015)</td>
<td>1. Tandem stance</td>
<td>1. Tandem stance x 2 condition (EO &amp; EC).</td>
<td>1. Time tandem stance maintained (s)</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>2. TUG</td>
<td>Trial length = 60s.</td>
<td>2. Time completed the task (s).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Significant difference in all conditions (tandem stance EO &amp; TUG p &lt; 0.00).</td>
</tr>
<tr>
<td>Kato-Narita et al. (2011)</td>
<td>BBS</td>
<td>Functional performance:</td>
<td>Variable</td>
<td>Significant difference only in moderate (CDR2) AD (non-faller group) compared to control healthy peers (p &lt; 0.00).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The 56-point BBS grades. There were 14 tasks including sitting, rising, transferring, reaching, picking up object from the floor, turning around in a full circle, stepping and standing on one leg.</td>
<td>Score based on specific time and distance requirements.</td>
<td></td>
</tr>
<tr>
<td>Kido et al. (2010)</td>
<td>SLS</td>
<td>Static postural stability:</td>
<td>One leg standing time (s)</td>
<td>Significant difference (p &lt; 0.00).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One leg standing time with EO. A maximum time of 60s. 2 trials was given and the shorter time was used for statistical analysis.</td>
<td></td>
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</tr>
<tr>
<td>Pettersson et al. (2005)</td>
<td>1. BBS</td>
<td>Functional performance:</td>
<td>Variables</td>
<td>Significant difference for TUG (p ≤ 0.05).</td>
</tr>
<tr>
<td></td>
<td>2. TUG</td>
<td>The 56-point BBS grades. There were 14 tasks including sitting, rising, transferring, reaching, picking up object from the floor, turning around in a full circle, stepping and standing on one</td>
<td>1. Score base on specific time and distance requirements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Time completed the task (s).</td>
</tr>
</tbody>
</table>
### Functional performance:

- **BBS (Pettersson et al., 2002)**
  1. The 56-point BBS grades. There were 14 tasks including sitting, rising, transferring, reaching, picking up object from the floor, turning around in a full circle, stepping and standing on one leg.
  2. TUG measures the time taken to rise from an armchair, walk 3m, turn, walk back and sit down again.
  3. The participants were asked to walk twice in a figure of 8 pattern, twice following the marked figure on the floor.

- **Variables:**
  1. Score based on specific time and distance requirements.
  2. Time to complete the task(s).
  3. Time to complete the task(s).

- **Significant difference for all clinical tests (p < 0.00).**

---

### Dynamic postural stability:

- **Suttanon et al. (2012a)**
  1. FR test
  2. Step test
  3. TUG

- **Variables:**
  1. The distance reached from starting position (cm).
  2. The number of steps.
  3. Time completed the task(s).

- **Significant difference (p < 0.00) in all clinical measures.**
block as quickly as possible in 15s

Functional performance:

3. TUG measures the time taken to rise from a chair, walk 3m, turn, walk back and sit down again.

Notes. AD, Alzheimer Disease; BBS, Berg balance scale; NINCDS-ADRDA, National Institute of Neurological and Communicative Disorders and Stroke and Alzheimer’s Disease and Related Disorders Association; CDR, Clinical Dementia Rating. CS, Cross-Sectional; DSM, Diagnostic and Statistical Manual for mental disorder; EO, eyes open; EC, eyes closed, EOF, eyes open on foam surface; ECF, eyes closed on foam surface; FR, functional reach test; FT, foot tapping; FTH, finger to thumb; ICD-10, International Classification of Disease and Related Health Problems 10th Revision; LOS, limit of stability; LS, Longitudinal study; MMSE, Mini-Mental State Examination; NA, not available; POMA, Performance-Oriented Mobility Assessment; PPA, Physiological Profile Approach; PS, pronation and supination; Q, quality; SLS, single leg stance; Ts, trials; TUG, Timed Up and Go test; TW, tandem walk.
4.3.8 Measurement of contributing factors

The factors potentially impacting on postural stability, to be measured, were divided into five categories Table 4.4, namely: brain pathology (regional blood flow) (Nakamura et al., 1997), cognitive (for instance measured by MMSE) (Chong et al., 1999a; Gago et al., 2014; Leandri et al., 2009), attention demand (i.e. dual task activity - for instance carrying a full cup of water) (de Andrade et al., 2014; Manckoundia et al., 2006; Pettersson et al., 2005; Suttanon et al., 2012a), motor (lower limb muscle activity and latency) (Chong et al., 1999a), and preparatory postural activity and reaction time measured with EMG (Elble & Leffler, 2000), and sensory (availability of vision, somato-sensation and vestibular) (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014; Leandri et al., 2009; Mignardot et al., 2014; Suttanon et al., 2012a).
Table 4.4 Factors identified that contributed to reduced postural stability

<table>
<thead>
<tr>
<th>Study</th>
<th>Alzheimer group</th>
<th>Control group</th>
<th>Task and/or Postural stability measure</th>
<th>Causes/ Factors association measures</th>
<th>Statistics &amp; Results</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Brain pathology</td>
<td></td>
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<tr>
<td>Nakamura et al. (1997)</td>
<td>n = 15</td>
<td>n = 15</td>
<td>Romberg stance for 60 seconds.</td>
<td>-rCBF in the cortex (CDR1-mild)</td>
<td>Pearson correlation</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>age, yr = 75.9 (3.6)</td>
<td>age, yr = 77.1 (3.4)</td>
<td>RMS</td>
<td>-rCBF in the cortex and frontal lobe (CDR2-moderate)</td>
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<tr>
<td></td>
<td>Sex = 5M, 10F</td>
<td>Sex = 5M, 10F</td>
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<tr>
<td></td>
<td>MMSE = 18.6 (1.7)</td>
<td>MMSE = 27.4 (1.3)</td>
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<tr>
<td></td>
<td>CDR = 1</td>
<td>CDR = 2</td>
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<tr>
<td></td>
<td>Duration of illness, yr = 2.2 (1.8)</td>
<td>Duration of illness, yr = 4.3 (1.6)</td>
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<tr>
<td></td>
<td>Diagnosis = NINCDS-ADRDA &amp; DSM-III</td>
<td>Diagnosis probable AD = NINCDS-ADRDA</td>
<td>PTP COM sway amplitude</td>
<td>-MMSE score</td>
<td>Pearson correlation</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Recruitment = Inpatients of geriatrics hospitals</td>
<td>Recruitment = Unable to determine</td>
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<tr>
<td>2. Cognitive</td>
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<tr>
<td>Chong et al. (1999)</td>
<td>n = 11</td>
<td>n = 17</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>age, yr = 72 (10)</td>
<td>age, yr = 65 (6)</td>
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<tr>
<td></td>
<td>Sex = 5M, 6F</td>
<td>Sex = 9M, 8F</td>
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<tr>
<td></td>
<td>MMSE = 19 (5)</td>
<td>MMSE = Unable to determine</td>
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<tr>
<td></td>
<td>Diagnosis probable AD = NINCDS-ADRDA</td>
<td>Recruitment = Unable to determine</td>
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</tbody>
</table>

- Significant negative correlation (p < 0.05, rs = ±0.7). Postural sway increase with progression of CDR in AD.
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Description</th>
<th>COP Position</th>
<th>ADAS-cog</th>
<th>Recruitment</th>
<th>Outcome Measure</th>
</tr>
</thead>
</table>
| Leandri et al. (2009) | Duration of illness = Not reported  
Recruitment = Unable to determine  
n = 15  
age, yr = 77.6 (range 69-84)  
Sex = 7M, 8F  
MMSE = Not available  
Diagnosis = NINCDS-ADRDA & DSM-IV  
Duration of illness = 2 yr  
Recruitment = Unable to determine | COP position based in EO and EC conditions  
-AP COP path (mm)  
-ML COP displacement (mm)  
-COP area (mm²) | Bivariate Spearman correlation coefficient  
Positive linear correlation (p < 0.05,  
rs = > ± 0.5-0.7)  
(ADAS-cog Orientation and COP_AP sway EC but not in EO). Moderate correlation between  
(following command AP EO, spoken words AP EO, Instruction recollection COP area EC), no correlation for  
the other variables.  
Spearman test | +/- |
| Gago et al. (2014)    | ADNF  
n = 9  
age, yr = 73.6 (8.7)  
Sex = 2M, 7F  
CDR = 1 (range 0.5 - 2)  
Duration of illness, yr = 2.3 (1.9) | Kinetics variables  
-CDR | No correlation  
(p = 0.72) | - |
CDR = 2 (range 0.5 - 2)  
Duration of illness, yr = 2.8 (1.5)  
Diagnosis = DSM-IV and NINCDS/ADRDA  
Recruitment = Hospital outpatient neurology department  

3. Attention demand  
de Andrade et al. (2014)  
n = 12  
age, yr = 72.2 (7.3)  
Sex = 3M, 9F  
MMSE = 20.7 (4.0)  
Diagnosis = DSM-IV/ICD-10  
Duration of illness = Not reported  
Recruitment = Participants in specific physical activity programme  

n = 13  
age, yr = 65.8 (4.5)  
Sex = 6M, 7F  
MMSE = 27.6 (2.5)  
Recruitment = Participants in specific physical activity programme  

- COP displacement (mm)  
- COP area (mm²)  
Dual task - Counting backwards by one digit from 30.  
Mann-Whitney post hoc test  
Significant differences in number of errors in the cognitive task (p ≤ 0.00). AD more errors than healthy controls.  

Manckoundia et al. (2006)  
n = 13  
age, yr = 79.7 (5.1)  
Sex = 6M, 7F  
MMSE = 21 (2)  
Diagnosis = NINCDS-ADRDA & DSM-IV  
Duration of illness = NA  
Recruitment = Living at home or in a nursing home specialising in AD  

n = 17  
age, yr = 78.5 (4.4)  
Sex = 9M, 8F  
MMSE = 28.5 (4)  
Recruitment = Community  

Upright stance - COP displacement (mm)  
- COP area (mm²)  
Dual task - The differences between ST: upright stance and DT: upright stance and answer 3 questions about the video sequence  
Wilcoxon matched pair test  
Significant difference (p < 0.05).
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Size</th>
<th>Age, yr (±SD)</th>
<th>Sex</th>
<th>MMSE (±SD)</th>
<th>Diagnosis</th>
<th>Duration of Illness</th>
<th>Recruitment</th>
<th>TUG, Distance (s)</th>
<th>Dual Task</th>
<th>Statistical Test</th>
<th>Significant Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suttanon et al.</td>
<td>n = 25, age, yr = 80.4, Sex = 9M, 16F, MMSE = 21.1</td>
<td>n = 25, age, yr = 80.4, Sex = 9M, 16F, MMSE = 29.2</td>
<td>TUG, distance (s)</td>
<td>Dual task - Counting backward by 3s, - Carrying full cup of water</td>
<td>Independent sample t test</td>
<td>Significant after Bonferroni adjustment (p ≤ 0.00).</td>
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<tr>
<td>Pettersson et al.</td>
<td>n = 22, age, yr = 68 (9.9), Sex = 12M, 10F, MMSE = 24 (range 17-30)</td>
<td>n = 33, age, yr = 57 (9.2), Sex = 20M, 13F, MMSE = 29 (range 27-30)</td>
<td>TUG, distance (s)</td>
<td>Dual task - Carrying a cup of water</td>
<td>Kruskal-Wallis ANOVA</td>
<td>Significant difference (p ≤ 0.05).</td>
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</tr>
<tr>
<td>Chong et al.</td>
<td>n = 11, age, yr = 73 (10), Sex = 6M, 5F, MMSE = 19 (6)</td>
<td>n = 12, age, yr = 62 (5), Sex = 7M, 5F, MMSE = Unable to determine</td>
<td>Motor control test: The influence of changes in support conditions on postural set</td>
<td>Muscle activity and latency: - Tibialis anterior response, - Soleus response, - Tibialis anterior activity</td>
<td>Repeated measures ANOVA</td>
<td>No significant difference in muscle activity and latency in all task and conditions (p &gt; 0.05). AD</td>
<td></td>
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</tr>
</tbody>
</table>
Recruitment = Unable to determine

Elble and Leffler (2000) n = 11
- Age, yr = 76.3 (4.9)
- Sex = 6M, 5F
- MMSE = 25 (2.3)
- Diagnosis = NINCDS-ADRDA
- Duration of illness = Not reported
- Recruitment = Outpatients of Department of Neurology and The Centre for AD and related disorders
- Analysis system

Elble and Leffler (2000) n = 27
- Age, yr = 74.7 (5.7)
- Sex = 15M, 12F
- MMSE = 28.70 (1.3)
- Recruitment = Community

Participants did not have difficulty in changing postural set. During holding trials, AD reduced muscle activity as compared to healthy peers control group.

Repeated measures ANOVA

Preparatory postural activity:
- Preparatory postural activity (was estimated by measuring the net ankle torque and the rate of change of net ankle torque at the time of the initial change in bar force)

Repeated measures ANOVA after log 10 transform

Significant difference (p < 0.00). AD having longer mean RT.

5. Sensory system
Chong et al. (1999) n = 11
- Age, yr = 72 (10)
- Sex = 5M, 6F

Chi square

/-+

Repeated measure ANOVA after log 10 transform

Sensory system
- Vision, somatosensory & vestibular (C2, C3, C4)
<table>
<thead>
<tr>
<th></th>
<th>Diagnosis</th>
<th>Recruitment</th>
<th>Romberg ratio (Comparison EO and EC conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE = 19 (5)</td>
<td>Probable AD</td>
<td>Unable to determine</td>
<td>C4, C5, C6</td>
</tr>
<tr>
<td>NINCDS-ADRDHA</td>
<td></td>
<td></td>
<td>-Romberg ratio</td>
</tr>
<tr>
<td>Duration of illness =</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Not reported</td>
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<tr>
<td>Recruitment = Unable to</td>
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<td></td>
</tr>
<tr>
<td>determine</td>
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</tbody>
</table>

Dickin and Rose (2004)  

<table>
<thead>
<tr>
<th></th>
<th>Diagnosis</th>
<th>Recruitment</th>
<th>Romberg ratio (Comparison EO and EC conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE = 22.2 (2.8)</td>
<td>NINCDS-ADRDHA</td>
<td></td>
<td>C2 AD less sway than in control healthy peers.</td>
</tr>
<tr>
<td>Sex = Not reported</td>
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<tr>
<td>age, yr = 82.0 (3.6)</td>
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<tr>
<td>n = 6</td>
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</tbody>
</table>

Dickin and Rose (2004)  

<table>
<thead>
<tr>
<th></th>
<th>Diagnosis</th>
<th>Recruitment</th>
<th>Romberg ratio (Comparison EO and EC conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE = 29.0 (0.7)</td>
<td>Mild SDAT</td>
<td></td>
<td>C2 AD less sway than in control healthy peers.</td>
</tr>
<tr>
<td>Sex = Not reported</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>age, yr = 76.5 (3.8)</td>
<td></td>
<td></td>
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<tr>
<td>n = 10</td>
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</tbody>
</table>

Dickin and Rose (2004)  

<table>
<thead>
<tr>
<th></th>
<th>Diagnosis</th>
<th>Recruitment</th>
<th>Romberg ratio (Comparison EO and EC conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE = 10.2 (2.6)</td>
<td>Mild SDAT</td>
<td></td>
<td>C2 AD less sway than in control healthy peers.</td>
</tr>
<tr>
<td>Sex = Not reported</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>age, yr = 79.3 (5.5)</td>
<td></td>
<td></td>
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<tr>
<td>n = 6</td>
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</tbody>
</table>

Dickin and Rose (2004)  

<table>
<thead>
<tr>
<th></th>
<th>Diagnosis</th>
<th>Recruitment</th>
<th>Romberg ratio (Comparison EO and EC conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE = 29.0 (0.7)</td>
<td>Mild SDAT</td>
<td></td>
<td>C2 AD less sway than in control healthy peers.</td>
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<tr>
<td>Sex = Not reported</td>
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<tr>
<td>age, yr = 76.5 (3.8)</td>
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<tr>
<td>n = 10</td>
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<tr>
<td>Study</td>
<td>Group</td>
<td>Age (yr)</td>
<td>Sex</td>
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<tr>
<td>Gago et al. (2014)</td>
<td>ADNF</td>
<td>73.6 (8.7)</td>
<td>2M, 7F</td>
</tr>
<tr>
<td></td>
<td>ADF</td>
<td>77.6 (4.8)</td>
<td>4M, 7F</td>
</tr>
</tbody>
</table>

Note: All differences were not significantly different (p > 0.01-0.05).
<table>
<thead>
<tr>
<th>Study</th>
<th>n</th>
<th>Age (yr) (range)</th>
<th>Sex (M:F)</th>
<th>MMSE</th>
<th>Diagnosis</th>
<th>Duration of Illness</th>
<th>Recruitment</th>
<th>Variables compared</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leandri et al. (2009)</td>
<td>n = 15</td>
<td>77.6 (69-84)</td>
<td>7M:8F</td>
<td>Not available</td>
<td>NINCDS-ADRDA &amp; DSM-IV</td>
<td>2 yr</td>
<td>Unable to determine</td>
<td>ANOVA: Significant difference in all variables with EC (p &lt; 0.01).</td>
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<td></td>
<td>- Vision EC &amp; Romberg ratio (Comparison EO and EC conditions)</td>
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<td>- COP AP sway (mm)</td>
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<td>- COP ML sway (mm)</td>
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<td>- COP ellipse area (mm²)</td>
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<td>+/-</td>
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<tr>
<td>Mignardot et al. (2014)</td>
<td>n = 243</td>
<td>83 (5.8)</td>
<td>93M:150F</td>
<td>19.3 (4.4)</td>
<td>NINCDS-ADRDA &amp; DSM-IV</td>
<td>Not reported</td>
<td>Memory clinic, Angers University Hospital</td>
<td>MANCOVA: Significant difference COP AP sway (p = 0.46).</td>
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<td>- AP COP velocity (AAMV) (mm.s⁻¹)</td>
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<td></td>
<td>- Vision (EC)</td>
<td></td>
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<tr>
<td></td>
<td>n = 228</td>
<td>72.5 (6.1)</td>
<td>136M:92F</td>
<td>28 (2.3)</td>
<td></td>
<td></td>
<td>Unable to determine</td>
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<td>+/-</td>
</tr>
<tr>
<td>Study</td>
<td>n = 25, age, yr = 80.4</td>
<td>n = 25, age, yr = 80.4</td>
<td>Sway (degree/sec) - Vision (EC on firm and foam surface)</td>
<td>Mann Whitney U test</td>
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<tr>
<td>Suttanon et al. (2012a)</td>
<td>Sex = 9M, 16F</td>
<td>Sex = 9M, 16F</td>
<td>Recruitment = Community and existing volunteer database from a research institute</td>
<td>Significant difference for EC firm (p = 0.04) &amp; for EC foam surface (p &lt; 0.01).</td>
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<tr>
<td></td>
<td>MMSE = 21.1</td>
<td>MMSE = 29.2</td>
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<tr>
<td></td>
<td>Diagnosis = NINCDS-ADRDA</td>
<td>Recruitment =</td>
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<tr>
<td></td>
<td>Duration of illness = Not reported</td>
<td>Community and</td>
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<td></td>
<td>Recruitment = Memory clinic and community</td>
<td>existing volunteer</td>
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</tbody>
</table>

**Notes.** Adapted from a systematic review (Mesbah et al., 2017)

+: significant correlation/ significant differences; -: no correlation/ no significant differences; +/-: mixed result.

AD, Alzheimer’s disease; ADAS-cog, Alzheimer's Disease Assessment Scale-Cognitive subscale; ADF, Alzheimer’s disease fall group; ANOVA, analysis of variance; AP, anterior-posterior; CDR, Clinical Dementia Rating; C1, Condition 1; C2, Condition 2; C3, Condition 3; C4, Condition 4; C5, Condition 5; C6, Condition 6; COM, centre of mass; COP, centre of pressure; DT, dual task; EO, eyes open; EC, eyes closed; IS, incongruent surface; IV, incongruent visual; MANCOVA, multivariate analysis of covariance; ML, medio-lateral; MMSE, Mini-Mental State Examination; N/A, not available; PTP, peak-to-peak; rCBF, regional central blood flow; RMS, root mean square; Sig., Significant; ST, single task; TUG, timed up and go test; RT, reaction time; ULRT, upper limb reaction time.
4.3.9 Quality

The quality of the eighteen studies is shown in Table 4.5. Two studies were of high quality, ranging from 78-83% of the total score, (Mignardot et al., 2014; Pettersson et al., 2005) whereas the other sixteen studies were of moderate quality, ranging from 50-72% of the total score (Allan et al., 2005; Chong et al., 1999; Chong et al., 1999a; de Andrade et al., 2014; Dickin & Rose, 2004; Elble & Leffler, 2000; Franssen et al., 1999; Gago et al., 2014; Gras et al., 2015; Kato-Narita et al., 2011; Kido et al., 2010; Leandri et al., 2009; Manckoundia et al., 2006; Nakamura et al., 1997; Pettersson et al., 2002; Suttanon et al., 2012a). Only four studies provided findings with adequate adjustment for confounding in the analyses (Allan et al., 2005; Franssen et al., 1999; Mignardot et al., 2014; Pettersson et al., 2005) Nine moderate quality studies lost scores due to unclear reporting of participant recruitment and selection (Allan et al., 2005; de Andrade et al., 2014; Elble & Leffler, 2000; Gras et al., 2015; Kato-Narita et al., 2011; Leandri et al., 2009; Manckoundia et al., 2006; Nakamura et al., 1997; Suttanon et al., 2012a).
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Notes: Av, Average; Y, yes (1); N, no (0); ø, unable to determine (0); >75%, high quality; 50-74%, moderate quality; <50% low quality
Research question 1

Eighteen studies met the inclusion and exclusion criteria to answer question one. These results were separated into two sections: Laboratory-based studies Table 4.2 and clinically-based studies Table 4.3. Of these eighteen studies, only one study used both laboratory- and clinically-based outcome measures (Suttanon et al., 2012a).

Laboratory-based measures

The static postural stability of those with mild to moderate Alzheimer’s disease was shown to be significantly reduced compared with control healthy peers (six studies) for the following measurements: centre of pressure, average, absolute, maximal velocity in anterior-posterior direction (Mignardot et al., 2014), percent equilibrium (Dickin & Rose, 2004), centre of pressure position-based variables (Leandri et al., 2009; Manckoundia et al., 2006), Root Mean Square (Nakamura et al., 1997) and sway velocity (Suttanon et al., 2012a). One of these studies was rated of high quality (Mignardot et al., 2014); the other five were moderate quality (Dickin & Rose, 2004; Leandri et al., 2009; Manckoundia et al., 2006; Nakamura et al., 1997; Suttanon et al., 2012a). No significant differences were found in five moderate quality studies for peak-to-peak centre of mass sway amplitude (Chong et al., 1999), centre of gravity movement velocity (Dickin & Rose, 2004), centre of mass-based measurement (Elble & Leffler, 2000; Gago et al., 2014) and centre of pressure-based measurement (de Andrade et al., 2014).

Dynamic postural stability measured by maximum excursion of limits of stability, percentage of limits of stability directional control (Suttanon et al., 2012a), and percent equilibrium were found to be significantly different (Dickin & Rose, 2004). No statistically significant difference was found between people with mild to moderate Alzheimer’s disease and control healthy peers for measures of peak-to-peak centre of mass sway amplitude (Chong et al., 1999), centre of gravity movement velocity (EO, support incongruent surface) (Dickin & Rose, 2004), centre of pressure-based variables (Gago et al., 2014), centre of mass displacement (Elble & Leffler, 2000) and movement velocity (Suttanon et al., 2012a). These studies were of moderate quality.
Functional, dynamic, postural stability was only measured in one laboratory study and there was no significant difference between groups as measured by the functional tests of sit to stand sway velocity on the NeuroCom Balance Master (Suttanon et al., 2012a).

**Clinical-based measures**

Table 4.3 reports the results of the eight clinically-based postural stability tests (Allan et al., 2005; Franssen et al., 1999; Gras et al., 2015; Kato-Narita et al., 2011; Kido et al., 2010; Pettersson et al., 2002; Pettersson et al., 2005; Suttanon et al., 2012a). All tests were measured with EO and on a flat surface. Static balance was significantly different in two moderate quality studies measured in one by tandem stance (Gras et al., 2015) and in the other by single leg stance (Kido et al., 2010).

Dynamic, postural stability was significantly reduced in older adults with mild to moderate Alzheimer’s disease compared to control healthy peers for the functional reach and Step Test in one moderate quality study (Suttanon et al., 2012a).

Functional performance of postural stability was significantly reduced compared to control healthy peers for the measures of Performance-Oriented Mobility Assessment (Allan et al., 2005), Berg Balance Scale (Kato-Narita et al., 2011; Pettersson et al., 2002), parametric rating scale for equilibrium and limb coordination test (Franssen et al., 1999), Timed Up and Go (Gras et al., 2015; Pettersson et al., 2002; Pettersson et al., 2005; Suttanon et al., 2012a) and figure of eight tests (Pettersson et al., 2002). However, when the Performance-Oriented Mobility Assessment was analysed, based on the level of cognitive impairment, they found no significant difference between those with mild Alzheimer’s disease and control healthy peers (Allan et al., 2005). One study was rated as high quality (Pettersson et al., 2005), and the remaining studies included in this review were of moderate quality. The high quality study, using clinically-based functional measures of postural stability (Berg Balance Scale), found no significant difference between the groups (Pettersson et al., 2005).
Research question 2

Twelve studies were included that measured the factors which impact on postural instability in people with mild to moderate Alzheimer’s disease (Table 4.4).

Brain pathology

Postural stability, measured by the Root Mean Square in Romberg stance, was significantly negatively correlated ($r = -0.5$, $p < 0.05$) with regional blood flow to the cortex in people with mild Alzheimer’s disease, and to the cortex and frontal lobe in people with moderate Alzheimer’s disease (Nakamura et al., 1997). This study was rated as being moderate quality.

Cognitive

Three moderate quality studies measured the correlation between postural stability and cognitive function (Chong et al., 1999; Gago et al., 2014; Leandri et al., 2009) and only the study by Leandri et al. (2009) found a significant positive correlation between some of the postural stability measured by the centre of pressure-based position and some items in cognitive function measured by ADAS-cog (Leandri et al., 2009). In this study, a positive linear correlation ($p < 0.05$) was found between 1) anterior-posterior centre of pressure during eyes closed and ADAS-cog orientation ($r_s = > ± 0.7$); 2) anterior-posterior centre of pressure during EO and ADAS-cog following command ($r_s = ± 0.5-0.7$); 3) anterior-posterior centre of pressure during EO and ADAS-cog spoken words ($r_s = ± 0.5-0.7$); and 4) centre of pressure area and ADAS-cog instruction recollection ($r_s = ± 0.5-0.7$) (Leandri et al., 2009).

Attention demand

The attention demand in dual task conditions significantly ($p < 0.05-≤ 0.00$) reduced the performance of postural stability in people with mild to moderate Alzheimer’s disease in four studies (de Andrade et al., 2014; Manckoundia et al., 2006; Pettersson et al., 2005; Suttanon et al., 2012a). The variables of postural stability used were: centre of pressure for static stability, and time measured in the Timed Up and Go test for functional stability while undertaking a second task, such as counting backward (de Andrade et al., 2014; Manckoundia et al., 2006; Pettersson et al., 2005; Suttanon et al., 2012a).
These studies were all judged moderate quality except Pettersson et al. (2005) which was rated as high quality (Pettersson et al., 2005).

**Motor**

Motor performance, including muscle activity and latency of muscle response of lower limb, preparatory postural activity, postural and upper limb reaction time during perturbation or changing position tasks were all measured in two moderate quality studies (Chong et al., 1999a; Elble & Leffler, 2000). Only the measurement of reaction time in upper limb and postural reaction times was found to be significantly greater (p < 0.00) in people with Alzheimer’s disease compared to control healthy peers in both 75% and 50% push and pull conditions (Elble & Leffler, 2000).

**Sensory**

The studies, which investigated sensory contribution to postural stability, using computerised posturography, demonstrated that, in the eyes closed and on normal firm surface conditions, significant differences between the groups were found in seven postural stability measurement studies; that is: for percent equilibrium (p≤0.01) (Dickin & Rose, 2004), total, maximum and mediolateral displacement of centre of mass (p = < 0.01) (Gago et al., 2014), centre of pressure position (p = < 0.01) (Leandri et al., 2009), and centre of pressure velocity (p < 0.01) (Mignardot et al., 2014), and sway in modified Clinical Test of Sensory Interaction of Balance (mCTSIB) (p = 0.04) (Suttanon et al., 2012a). During the eyes closed tests, two studies reported that participants with Alzheimer’s disease swayed significantly more in the condition of quiet standing on a foam surface and on an incongruent surface with eyes closed, measured by percent equilibrium (p = ≤0.01-0.05) (Dickin & Rose, 2004) and sway (p < 0.01) (Suttanon et al., 2012a), respectively. No statistically significant difference was found between participants with Alzheimer’s disease and control healthy peers group for centre of gravity movement velocity (Dickin & Rose, 2004) and sway measurement (Suttanon et al., 2012a). All six studies were rated as being of moderate quality except one study by Mignardot et al. (2014) which was high quality (Mignardot et al., 2014).
The Romberg ratio, a measurement of eyes open divided by eyes closed (EO/EC), was significantly different between people with mild to moderate Alzheimer’s disease and control healthy peers in two studies, with the measurement of total, maximum and anterior-posterior displacement during standing on a flat surface, the measurement of total and anterior-posterior displacement on backward inclination (p = < 0.01-0.05) (Gago et al., 2014) and centre of pressure in anterior-posterior and ellipse area (p = < 0.01) (Leandri et al., 2009). Both studies were moderate quality.

Conversely, in one study, significant differences was found during the test of standing on a firm surface with eyes closed, and a comparison between eyes closed and EO during the Romberg stance between groups; that is, healthy peers swayed more than older adults with Alzheimer’s disease (Chong et al., 1999).

4.3.10 The strength of evidence

Eight studies found statistically significant findings for ten different variables of static postural stability and only three studies found no significant difference. These eight studies included one high and seven moderate quality studies (quality range 56-83%). Thus, there is strong evidence that static postural stability is reduced in older adults with mild to moderate Alzheimer’s disease compared to their healthy peers.

Inconsistent findings were found for dynamic postural stability as only two studies found significant differences (quality range 72-72%) and three studies were not significant (quality range 61-73%). Thus, there is weak evidence of dynamic postural stability being reduced in older adults with mild to moderate Alzheimer’s disease compared with control healthy peers.

With regard to functional postural stability, five moderate to high quality studies demonstrated significantly different findings (quality range 56-78%). Two studies found no significant differences. Thus, there is strong evidence that functional postural stability is reduced in older adults with mild to moderate Alzheimer’s disease compared with control healthy peers.
There was strong evidence for two factors contributing to postural instability in older adult with Alzheimer’s disease, namely attention demand and vision (standing with eyes closed on firm surface). Attention demand during a dual task activity was positively associated with postural instability in one high quality and three moderate quality studies (quality range 61-78%). Whereas postural stability performance, measured when standing on a firm surface with eyes closed, was significantly different in one high and four moderate quality studies (quality range 56-78%).

There was weak evidence for other factors, including brain pathology, cognitive function and motor performance as either there was only one study evaluating a similar contributing factor or there were less than three studies that found consistency with statistically significant differences, when comparing people with mild to moderate cognitive impairment and healthy peers.

4.4 Discussion

This systematic review aimed to explore and evaluate what has been published in the literature concerning postural stability in people with mild to moderate Alzheimer’s disease and contributing factors to postural instability compared to a control group of healthy peers. The results from this exercise show that people aged 68 years and above, who have been diagnosed with mild to moderate Alzheimer’s disease, have reduced static and functional postural stability compared with healthy peers when measured with laboratory and/or clinical outcome measures. Due to the heterogeneity of variables, populations and study designs used by studies to measure postural instability, a meta-analysis of the data was not possible.

Postural instability was significantly associated with attention demand and decreased visual input. Participants with mild to moderate Alzheimer’s disease either increase their focus on their postural stability during a measurement test, and thus make more errors in the concomitant cognitive task compared to healthy peers, or participants with mild to moderate Alzheimer’s disease sway more whilst doing a dual cognitive task compared to the control healthy peers (de Andrade et al., 2014; Manckoundia et al., 2006; Suttanon et al., 2012a). This reduced ability to focus on both a cognitive task and
postural stability increases the risk of falling. Moreover, postural instability increases with increments of cognitive load (Barra, Bray, Sahni, Golding, & Gresty, 2006). During the measurement of postural stability performance with eyes closed and a stable platform, older adults with mild to moderate Alzheimer’s disease rely on vestibular and somatosensory faculties to maintain postural stability.

The environment participants were recruited from is an importance consideration as it provides context with respect to the findings of this review. In one study, participants with mild to moderate Alzheimer’s disease were inpatients from a hospital, (Nakamura et al., 1997) while another two studies involved a combination of participants recruited from the community and long term care or nursing home facilities (Dickin & Rose, 2004; Manckoundia et al., 2006). Not unexpectedly, participants with mild to moderate Alzheimer’s disease living in a hospital had lower functional ability and poorer postural stability compared to those living in the community. The incidence of falling in nursing homes has been reported as high as 1.5 per person per year with the range of 0.2 to 3.6 falls per year, primarily due to multifactorial reasons (Rubenstein et al., 1994). It might be that participants who were frailer have greater postural instability than those people with mild to moderate Alzheimer’s disease who are still living in the community.

Some of the inconsistent findings of this review may be due to the heterogeneity of the participants with mild to moderate Alzheimer’s disease. For instance, the duration of participants having mild to moderate Alzheimer’s disease was only reported in four studies (range was from 1.8 to 6 years of illness) (Allan et al., 2005; Gago et al., 2014; Leandri et al., 2009; Nakamura et al., 1997). Nakamura and colleagues (Nakamura et al., 1997) grouped the participants with mild to moderate Alzheimer’s disease into two groups, mild cognitive impairment (MMSE mean (SD) 18.6 (1.7)) with a duration of illness of 2 years, and moderate cognitive impairment (MMSE mean (SD) 11.4 (2.6)) with a duration of illness of 4 years. Consideration of illness duration is important as a decline of cognitive function occurs over time; the disease progresses as people with Alzheimer’s disease age (Sloane et al., 2002). Participants who have lived with mild to moderate Alzheimer’s disease for a long duration may have reduced postural stability compared to those who have more recently been diagnosed with Alzheimer’s disease.
Moreover, MMSE is influenced by education; therefore, a higher level of education might conceal the cognitive impairment (Fillenbaum, Hughes, Heyman, George, & Blazer, 1988; Tombaugh & McIntyre, 1992). In the Leandri et al. study (2009), all participants with Alzheimer’s disease had at least 8 years of education which was categorised as a ‘high level of education’ (Roselli et al., 2009) however, there was unclear information with regard to the severity of their cognitive impairment (Leandri et al., 2009).

Moreover, the studies that utilised the MMSE were using different cut off points to classify mild cognitive impairment. For instance, participants in the Petterson et al. (2005) and Petterson et al. (2002) studies who had scored more than 27/30 were classified as having mild cognitive impairment. Whereas others studies used this specific cut off point of 27/30 for normal cognition, especially for highly educated participants (Galasko et al., 1990; Kukull et al., 1994). Therefore, while my aim was to explore factors affecting postural sway in people with mild to moderate cognitive impairment, there were studies that classified the same value as normal cognition, whereas others studies categorised this value as mild cognitive impairment. This is a limitation of my study and consensus on the cut off points for each impairment level would mitigate this issue.

The MMSE was used widely by the studies included in this review, possibly because it is an easy screening tool which identifies a level of cognitive impairment. However, the MMSE does not determine the cause of the underlying condition(s); i.e., it does not provide a diagnosis (Mitchell, 2009). Further evaluation by specific diagnostic tests would be necessary to confirm the underlying condition causing the mild to moderate cognitive impairment. Therefore, in one of the studies, while a mild to moderate cognitive impairment was present, it is not possible to say that this was due to Alzheimer’s disease. Consequently, this is also a limitation of this review (Mendiondo, Ashford, Kryscio, & Schmitt, 2000).

The studies in our review typically used the DSM -III and -IV when a diagnosis of Alzheimer’s disease was given (de Andrade et al., 2014; Gago et al., 2014; Leandri et
al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Nakamura et al., 1997; Pettersson et al., 2002; Pettersson et al., 2005). The DSM-V is, however, the latest edition published by the American Psychiatric Association. This edition presents criteria to identify the pre-dementia stage of cognitive impairment included within Mild Neurocognitive Disorders (Mild NCD) (American Psychiatric Association, 2013). These new criteria were developed as there was concern with the cognition and classification of the initial phase of cognitive disorders, which may lead to Major Neurocognitive Disorders (Major NCD) (i.e., comparable with a diagnosis of dementia). This criterion could strengthen the validity of being able to classify people as having mild to moderate cognitive impairment, especially when initially measured by the MMSE.

The presence of neurological symptoms other than mild to moderate Alzheimer’s disease may also influence stability. Postural instability was found to be high in people with mild to moderate Alzheimer’s disease compared to their healthy peers in four studies that excluded people who had extrapyramidal presentations (Franssen et al., 1999; Leandri et al., 2009; Pettersson et al., 2002; Suttanon et al., 2012a). However, three studies found that people with mild to moderate Alzheimer’s disease, who did not have extrapyramidal presentations, had similar postural stability performance to their healthy peers (Chong et al., 1999; Chong et al., 1999a; Dickin & Rose, 2004). The similar performance of postural stability between mild to moderate Alzheimer’s disease sufferers and their healthy peers in these three studies could be due to small sample sizes (n = 25), (Chong et al., 1999a) n = 23, (Chong et al., 1999) and n = 22 (Dickin & Rose, 2004)). In a study by Nakamura et al. (1997), two participants with mild (n = 2/15) and seven participants with moderate (n = 7/15) Alzheimer’s disease had extrapyramidal presentations while others did not (Nakamura et al., 1997). This study found high postural instability in the participants with mild to moderate Alzheimer’s disease, which suggests that postural instability was being influenced by the presence of extrapyramidal signs. Interestingly, extrapyramidal signs are reported to have a high prevalence in older adults with Parkinsonism who might also develop Alzheimer’s disease in the latter stages, with a characteristic of postural instability (Tosto, Monsell, Hawes, & Mayeux, 2015).
Six studies included participants who were age-matched with healthy peers (Allan et al., 2005; Gago et al., 2014; Gras et al., 2015; Nakamura et al., 1997; Pettersson et al., 2002; Suttanon et al., 2012a). In three other studies there were age differences (range 5 to 10 years) between groups (Franssen et al., 1999; Kido et al., 2010; Mignardot et al., 2014), and in two of them there were statistically significant age differences (p < 0.00) (Kido et al., 2010; Mignardot et al., 2014), with participants classified as having mild to moderate Alzheimer’s disease being older than the healthy peers in the control group. These three studies found high postural instability in people with mild to moderate Alzheimer’s disease compared to healthy peers (Franssen et al., 1999; Kido et al., 2010; Mignardot et al., 2014). Previous studies have found that the magnitude of change in postural stability is highly influenced by age; i.e., the older the person the greater the postural instability appears to be (Gill et al., 2001; Gu, Schultz, Shepard, & Alexander, 1996; Hegeman, Shapkova, Honegger, & Allum, 2006; Hytönen, Pyykkö, Aalto, & Starck, 1993). Therefore, if the unmatched control group is significantly younger, any postural instability differences observed will be inflated.

In four of the studies, the control healthy (non-Alzheimer’s disease) peer group were reported to have one or more medical problems, such as hypertension and diabetes, and these conditions could have impacted on their postural stability and thus the findings of this review (Allan et al., 2005; Elble & Leffler, 2000; Kato-Narita et al., 2011; Mignardot et al., 2014). Admittedly, recruiting adults with no underlying medical conditions, and also of a comparable age to the participants with mild to moderate Alzheimer’s disease, is logistically difficult. However, it is possible that this factor has influenced the outcomes of these respective studies and, in particular, the reported ‘non-difference’ results.

Factors, such as duration of illnesses, severity of cognitive decline, age, the presence of neurological and medical problems, were rarely controlled for and thus potentially confound the findings of this review. Confounders are the characteristics that could change reliability of the final results (Maldonado & Greenland, 1993). I acknowledge that collecting data from a cognitively challenged population is difficult, yet controlling
for factors known to confound results is considered to be important for the correct interpretation of findings.

Interpreting the results of this review was challenging for two reasons. There is a lack of consensus in the variables chosen to measure postural stability between researchers and this meant that a meta-analysis could not be undertaken. A consensus statement to standardise measures of postural stability is therefore recommended. Furthermore, there is limited evidence to demonstrate the robustness of some outcomes to measure specific variables. For example, only Mignardot et al. (2004) described the accuracy of the centre of pressure velocity variable which was chosen as the primary outcome to differentiate changes in postural stability in people with mild to moderate Alzheimer’s disease (Deschamps et al., 2014; Mignardot et al., 2014). This study also explored the usefulness of centre of pressure velocity-based variables in people with mild to moderate Alzheimer’s disease prior to their observational study (Deschamps et al., 2014). They found that centre of pressure velocity was an excellent variable to compare the differences in postural stability between the study group with mild to moderate Alzheimer’s disease with mild to moderate cognitive impairment and the control group of healthy peers in regard to visual condition, age and cognitive function (Mignardot et al., 2014). The previous studies also found the accuracy of velocity-based variables to measure the performance of postural stability (Jeka, Kiemel, Creath, Horak, & Peterka, 2004; Raymakers et al., 2005). The accuracy of velocity information may be attributable to the proprioception, tactile, and visual systems, all of which are influenced by velocity (Jeka et al., 2004; Raymakers et al., 2005). Furthermore, one study found that sway velocity was more altered and could be used to discriminate the differences between those with mild to moderate Alzheimer’s disease compared to their cognitively healthy peers (Suttanon et al., 2012a).

This review shows that many outcome measures have been used to evaluate postural stability in people with mild to moderate Alzheimer’s disease (Table 4.2 and Table 4.3); however, only nine studies reported the validity and reliability of these measures for this population group and explicitly explained the protocol of the postural stability testing (Chong et al., 1999; Chong et al., 1999a; de Andrade et al., 2014; Elble &
Leffler, 2000; Franssen et al., 1999; Gago et al., 2014; Mignardot et al., 2014; Nakamura et al., 1997; Suttanon et al., 2012a). For example, in the study by Suttanon et al. (2012a), the researchers validated the tests for postural stability in older adults with mild to moderate Alzheimer’s disease (Suttanon et al., 2012a). This study investigated test retest reliability of the modified Clinical Test of Sensory Interaction on Balance, limits of stability using NeuroCom Balance Master, functional reach test, Step Test and Timed Up and Go test and found fair to excellent reliability of all measures (Suttanon et al., 2011). In another study by Franssen et al. (1999), the clinical instrument parametric rating scale for equilibrium and limb coordination, used to measure postural stability, was new. Intra-rater reliability of the measure was conducted within the same study and found significant correlation in each of the items scored by the same examiner (Franssen et al., 1999). The remaining nine studies only report that the instruments are validated for an older adult population. Therefore, while the review found strong evidence for static and functional postural instability in mild to moderate Alzheimer’s disease, and attention demand and vision as associate factors to postural instability, there was a paucity of data demonstrating the validity of outcome measures; for example, smart balance master, stabilometry, force platform (Techno Concept) and the Performance-Oriented Mobility Assessment (Sterke, Huisman, van Beeck, Looman, & van der Cammen, 2010; van Iersel, Benraad, & Olderikkert, 2007). If outcome measures that have not been validated are used, the level of impairment on the construct of interest (i.e., balance) remains uncertain. However, there is currently no gold standard outcome measures to evaluate postural stability in this population. Thus, more work is required to establish consensus on which are the measures of most promise and thus gold standard, and then to evaluate the psychometric properties of each of these in older adults with mild to moderate Alzheimer’s disease.

4.5 Findings synthesising and inferences

The review provided strong evidence that older adults with mild to moderate Alzheimer’s disease have reduced postural stability, i.e., static and functional stability. Therefore this result strengthens the need for an intervention to improve postural stability; thus, consequently, it is hoped that it would reduce the risk of falls.
The results from the systematic review informed the selection of the intervention for the proof of concept study as set out in Chapter 7. There was strong evidence that three factors associated with postural stability need to be focused on: 1) dual task activity that increases the need of attentional demand such as counting while walking. This kind of activity can also increase functional stability; and 2) vision (but not due to pathological changes such as cataracts) that could be improved by activities that challenge the vision; i.e., discourage the visual inputs such as closed eyes while standing; 3) static stability that could be trained through standing still with both feet apart, feet close together or in tandem stand.

The findings of the systematic review also suggest that the assessment of postural stability and risk of falling has to be a method that is able to evaluate these three factors (dual task activity, vision and static stability) of postural instability.

### 4.6 Summary

This systematic review of the literature was performed to elucidate postural instability, and the factors associated with postural instability in older adults with mild to moderate Alzheimer’s disease. This review found strong evidence that static and functional postural stability is reduced in people with mild to moderate Alzheimer’s disease compared to healthy peers. There was strong evidence that postural instability was associated with increasing attention demand (dual task) and the availability of visual input. Included studies typically had a small sample size (< 20) and only two studies were rated high quality with low risk of bias. Only twelve studies have identified and quantified factors associated with postural instability in this population, therefore there is a need for further research in this area. Consensus on outcome measure values for classifying normal cognition, mild and moderate cognitive impairment, and also the primary variables of interest for measuring postural instability in older adults with mild to moderate Alzheimer’s disease is required to enable pooling of data in the future. The DSM-V, the new criteria for dementia, should be used in the diagnosis phase to classify people with mild to moderate cognitive impairment, in addition to those with Major Neurocognitive Disorders. Furthermore, research to determine the psychometric properties of the primary outcome measure for each variable in this specific population...
is necessary: yet, there is currently no gold standard outcome measure to evaluate postural stability in this population. Thus these limitations suggest the synthesis of results from this review should be treated cautiously. Until consensus regarding a gold standard measure is reached, the degree of postural instability in this population and contributory factors that may be amenable to intervention will remain unclear.

Chapter 5, which follows, presents the psychometric properties study. The primary aim was to evaluate the validity of the Physiological Profile Approach and the Timed Up and Go test for use in older adults with memory impairment. These outcome measures are used in the final proof of concept study detailed in Chapter 7.
CHAPTER 5: Study 2

Psychometric properties studies: A pilot study

5.1 Introduction
This chapter describes the study that evaluated the psychometric properties of Physiological Profile Approach (PPA), the Timed Up and Go (TUG) test and computerised posturography in the older adult with memory impairment. There were two parts to this study. Part A investigated the concurrent validity of the three outcome measures. In Part B, the sensitivity and specificity of the PPA and the TUG test were assessed.

5.2 Aims of the psychometric properties studies
The purpose of this study was to investigate the validity of the PPA and the TUG test for use in older adults with self-reported memory loss.

The specific objectives of this study were to investigate:

- The concurrent validity of PPA and the TUG test with computerised posturography in older adults with self-reported memory loss.
- The ability of the PPA and the TUG test to distinguish between fallers and non-fallers in older adults with self-reported memory loss.

5.3 Hypothesis
The hypotheses of the study were:

- The PPA and the TUG Test will have good concurrent validity with computerised posturography testing in older adults with self-reported memory loss.
The above two measures (PPA and TUG test) will be able to distinguish between older adults with self-reported memory loss who have recurrent falls and those who have one or no falls.

5.4 Methods

5.4.1 Targeted population

The population included in this current study were older adults with mild to moderate cognitive impairment.

5.4.2 Study design

This study utilised a cross sectional study design.

5.4.3 Ethical approval

The study was approved by University of Otago Human Ethics Committee (Health): H14/035. Subsequently, an amendment was applied for and approved for conducting the study.

5.4.4 Inclusion criteria

Participants with the following criteria were included:

- Aged 65 years or older (55 years or older if Māori or Pacific Island). The difference in the age between the ethnic groups due to an ethnical health variance (Blakely et al., 2005).
- Had a diagnosis of Alzheimer’s disease (confirmed by their general practitioner) according to NINCDS-ADRDA criteria or had self-reported memory loss (this is explained in the recruitment section below (p. 153).
- Mild to moderate severity of cognitive impairment (Mini-Mental State Examination\(^5\) (MMSE) score \(\geq 10-28/30\)). (Folstein et al., 1975; Ries et al., 2010; Shigemori et al., 2010). The license obtained from Psychological Assessment Resources, Inc., Florida

\(^5\) The full questionnaire can be viewed in Folstein et al. (1975).
• Able to understand verbal instruction sufficiently to safely undergo postural stability testing (Mozley et al., 1999).
• Independently mobile for a distance of at least 5 metres (with or without walking devices).
• Free from musculoskeletal, cardiac and neurological impairments that would prevent the participant from doing the testing.
• Currently living in the community.

5.4.5 Exclusion criteria

The following were the exclusion criteria:

• Presence of musculoskeletal, cardiac and neurological impairments that would prevent the participant from doing the test.
• Score of Mini-Mental State Examination of < 10.

5.4.6 Participants recruitment

Potential participants were informed about the study via public advertising in local newspapers, local TV and radio online noticeboards, and local public noticeboards, such as at the local hospital, clinics, museums, churches, libraries, shopping markets, retirement villages, and via bulk email, meetings and newsletters distributed by the Alzheimer’s Society Otago, Age Concern Otago and the local Disability Information Service. Those wishing to participate were asked to contact the School of Physiotherapy Clinical Research Administrator via telephone or email. The administrator briefly screened volunteers by telephone for eligibility (using a standardised telephone eligibility questionnaire and obtained contact details. To those who appeared to be eligible she sent a study information sheet and consent form. These potential participants were then contacted by myself. I explained the study further and sought questions, ensured eligibility, and participant’s willingness to be involved, and arranged a first appointment visit as appropriate.

Recruitment of participants was a challenge as after 6 months, we had only received four phone calls and only three people were eligible to be included in the study. I then
consulted further with the managers of the retirement villages, dementia care units and Long Term Care facilities in regard to my recruitment strategy. The outcome of these discussions was that I needed to change the wording of our recruitment advertising to “older adults who self-reported memory loss”. The reasons for this and the implications it had on this study are discussed in the discussion section below. An application seeking approval for the amended wording was sent to the Ethics Committee and was approved.

5.4.7 The researcher and the research assistant

I conducted the screening and all the testing, accompanied and assisted by a trained research assistant. I am a Malaysian registered physiotherapist, with temporary registration with the New Zealand Physiotherapy Board and have been working in the area of geriatrics for 8 years.

5.4.8 Screening of the Participants

Following the recruitment process, participants were provided with an appointment for testing. If required (depending on the level of cognitive impairment provisionally established during the phone interview), participants were encouraged to be accompanied by a support person to assist them; for example, with answering questions and assisting the participant to understand what was required of them. At this first appointment, the participant was provided with an opportunity to ask questions and, if still happy to participate, was asked to sign consent. The following processes then took place: 1) Collection of self-reported (or support person proxy reported) demographic data; namely, age, sex, marital status, ethnicity, height, weight, education level, duration of having memory loss, medical status, history of falls and medications; 2) Testing of cognitive function using the Mini-Mental State Examination (Folstein et al., 1975). In this study, a fall was defined as an unexpected event in which the person comes to rest inadvertently on the ground, floor, or other lower level (Lamb et al. (2005), p. 1618) which had occurred in the last 12 months.
5.4.9 Testing procedure and outcome measures

This section explains the testing procedure and the outcome measures used in this study. As mentioned earlier in Chapter 4, older adults with Alzheimer disease have reduced static and functional postural stability. The systematic review suggested that the evaluation of postural stability should be able to assess three factors of postural instability namely dual task activity, influence of vision on postural stability and static stability. However, the current study only evaluated psychometric properties of outcome measures that were able to measure vision and static stability. I acknowledge this as a study limitation because the current study and the systematic review (Chapter 4) were conducted concurrently. At the time the results of the systematic review were finalised, it was too late to include TUG cognitive (to measure dual task) in this psychometric study.

Testing Procedure

Testing occurred at two sites, the Balance Clinic at the School of Physiotherapy and the Long Term Care Facility at a local rest home. Participants were encouraged to be accompanied by a support person who could assist and support the participant during testing. At the start of the testing procedure each test was demonstrated to the participant to increase their understanding of it.

Each participant was then tested using static long platform of computerised posturography (Neurocom Balance Master, Neurocom International Inc., USA), the PPA and the TUG test. These tests were carried out in a random order, the order being assigned by a computerised random programme. Participants were allowed to rest between tests and use walking aids during the test as needed.

The protocol of the testing was based on the standardised procedures published for that test and standardised instructions were used with each participant. The performances of the PPA and TUG test were recorded on the study scoring sheet. Data from the posturography testing determined by the accompanying software and the data were saved as a pdf file downloaded from the generated computer that had been linked to the posturography.
Mini Mental State Examination

The MMSE is comprise of two sub-sections: 1) the first section requires verbal responses to test orientation, registration, attention and calculation; and 2) the second section, that is to test language, by testing ability to recall name, follow verbal and three-stage commands, write a complete sentence, and copy a complex polygon similar to Bender-Gestalt Figure (Folstein et al., 1975). The maximum score for the first section is 21 and the second section is 9 with a total score of 30 (maximum). The score range has been divided into normal, mild, moderate and severe cognitive impairment with scores of 27-30, 18-28, 10-17 and < 10, respectively (Folstein et al., 1975). For the purpose of this study and given the variability of cut off in the literature, I employed a cut off range of 10 to28 to indicate mild to moderate cognitive impairment (Folstein et al., 1975; Ries et al., 2010; Shigemori et al., 2010).

Computerised posturography

*Figure 5.1* illustrated computerized posturography with long force plate equipment. Computerised posturography aims to quantify postural sway, measured on a force plate, during the performance of functional activities, for example, walking. Postural sway was quantified by measurement of displacement of the body’s centre of pressure (COP) on the force plate, the force data are stored in a computer for subsequent analysis (Horak, 1987, 1997, 2006; Mancini & Horak, 2010; Shumway-Cook & Woollacott, 2007; Visser et al., 2008). The projection of the COP along the horizontal plate is calculated as a function of time. Data on the position of the COP versus time can be used to compute the trajectory of COP and speed (Balance Manager System, 2005). The outputs are compared with the performance of normal individuals in a similar age range (Balance Manager System, 2005).
Although the frequency of the COP signal is dependent on the task being investigated, normally 100 Hz frequency is set (Duarte & Freitas, 2010). There is no standardisation of the number of trials of each test required to measure COP, but two to four trials are recommended (Lafond et al., 2004; Corriveau et al., 2000). For my study I used three trials for all the tests except the test of limit of stability (LOS), for which only one trial was used as there was a default by the equipment. The period of data collection is recommended to be from a few seconds to two minutes depending on the task (Lafond et al., 2004; Corriveau et al., 2000; Rugelj et al., 2007). For testing quiet standing in older adults, 30 seconds has been suggested to avoid fatigue effects. The position of the feet is important in investigating postural stability. Standardisation of feet position was based on the participant’s self-selected comfortable position within their shoulder width, considered as a natural standing posture (Duarte & Freitas, 2010).

Five tests were undertaken on the computerised posturography (NeuroCom International, Inc) (Balance Manager System, 2005) equipment: (i) modified Clinical Test of Sensory Interaction on Balance (mCTSIB), (ii) sit to stand, (iii) step quick turn, (iv) walk across and (v) limit of stability. The test was first demonstrated to the participant. The key element in the instructions were the use of simple commands with
A full description of the testing procedures for these tests is given below:

**Modified clinical test of sensory interaction on balance (mCTSIB)**

Modified clinical test of sensory interaction on balance (mCTSIB) was used to measure postural sway under four sensory conditions 1) eyes open (EO) and 2) eyes closed (EC) whilst standing on 1) a firm surface and 2) a foam surface; each participant undertook three trials, standing still for 10 seconds. This measure was not used in this research to identify specific sensory deficits (somatosensory, visual and vestibular) (Buatois, Gueguen, Gauchard, Benetos, & Perrin, 2006; Horak, 1987, 1997; Shepard & Telian, 1995; Shumway-Cook & Woollacott, 2007), but to gain information about global deficits in sensory integration contributing to postural stability. The variable used in this test was the centre of gravity sway velocity (degree/second) (Chong et al., 1999; de Andrade et al., 2014; Dickin & Rose, 2004; Elble & Leffler, 2000; Gago et al., 2014; Gras et al., 2015; Isableu et al., 2003; Lacour et al., 1997; Leandri et al., 2009; Manckoundia et al., 2006; Mignardot et al., 2014; Suttanon et al., 2011; Suttanon et al., 2012a). The smaller the sway velocity, the greater the instability. The best result from each test was used for statistical analysis.

**Sit to stand**

The sit to stand test measures the ability of the participant to stand up from a seated position without losing balance. The participant was asked to sit on a box that was placed at the centre of the measurement platform with the knees positioned in 90° flexion (Darwish, El-Tamawy, Ahmed, & Rasmy, 2013; Luque-Siles et al., 2016; Mazza, Zok, & Della Croce, 2005; Suttanon et al., 2011; Suttanon et al., 2012a). On seeing a visual cue generated by the computer the participant had to stand up and hold a standing position for 5 seconds (Mazza et al., 2005; Suttanon et al., 2012a). Three trials were undertaken and the best score for each variable measured during this task was computed for statistical analysis. The outcome variables from this test were: a) weight transfer time (seconds), b) rising index (%), and c) sway velocity (degrees/second), as described below (Darwish et al., 2013; Luque-Siles et al., 2016; Suttanon et al., 2011; Suttanon et al., 2012a).
**Weight transfer time:** Weight transfer time is the time (in seconds) from the onset of the visual cue to move until weight is accepted on the feet in preparation for standing (from seat to feet; not including the rise phase) (de Haart, Geurts, Dault, Nienhuis, & Duysens, 2005; Tessem, Hagstrøm, & Fallang, 2007). Slow weight transfer reduces the ability to use momentum to move centre of gravity forward, and increases the need for lower limb muscle strength and power (Pai, Naughton, Chang, & Rogers, 1994). The lowest score, indicating best performance, was used for statistical analysis.

**Rising index:** Rising index is the force produced by the lower limbs to rise and achieve a successful full standing position (rising phase) (Lindemann et al., 2003). It is expressed as a percentage of body weight. Higher scores are indicative of greater lower limb power (Luque-Siles et al., 2016). Quadriceps strength shows good correlations with the average mechanical power used in a rising phase (Lindemann et al., 2003). The highest score, indicating the greatest force was used for statistical analysis.

**Sway velocity:** Sway velocity is the amount of sway exhibited by the patient in the 5 seconds following the stand to rise phase. Similar to the mCTSIB measure, the sway velocity is the ratio of the distance travelled by the centre of gravity (expressed in degrees) to the time taken (Luque-Siles et al., 2016; Suttanon et al., 2012a; Suttanon et al., 2013a). The greater the participant’s sway, the higher the sway velocity score and thus the greater the person’s instability (Luque-Siles et al., 2016). The lowest score of sway velocity was used for statistical analysis.

**Step quick turn**
Step quick turn is a test of stability measure in turn time (seconds) and turn sway (degrees per second) when taking a few steps (at their usual pace) then turning and walking back to the starting position (Darwish et al., 2013; Fjeldstad, Pardo, Frederiksen, Bemben, & Bemben, 2009; Suttanon et al., 2012a; Suttanon et al., 2013a). Performance was evaluated based on turning to both side: left and right (Fjeldstad et al., 2009; Suttanon et al., 2012a; Suttanon et al., 2013a). The best measures of turn time (seconds) and turn sway (degrees/second) were recorded from three trials in each
direction and were used for analyses. The short turn time and low sway score indicate high stability.

**Walk across**

Walk across is a test of walking at a comfortable speed across the long plate. The measurements taken were step width (cm), step length (cm), and walking speed (cm/second) (Fjeldstad et al., 2009; Suttanon et al., 2012a; Suttanon et al., 2013a). Step width is an indication of the size of the person’s base of support. A smaller score indicates better postural stability. Completing the task quickly indicates longer step lengths were used which is indicative of a better performance.

**Limit of stability**

Limits of stability (LOS) is a test of moving in eight directions toward a pre-set target. The measurements taken were speed and oscillation of weight shift (movement of centre of gravity within the body’s LOS) (Błaszczyk et al., 2014; Suttanon et al., 2011; Suttanon et al., 2012a). All eight directions were tested once. The outcome variables include: 1) reaction time measured in seconds, is the time between the starting point to move (the centre of gravity) and the beginning of execution of movement. A low score indicates good performance; 2) movement velocity measured in degrees per second, that is, the average speed of centre of gravity movement. Again a low score indicates good performance; and 3) endpoint excursion measured by percentage of (EPE); 4) percentage of maximum excursion (MXE) is the maximum excursion of the centre of gravity shift within the base of support; that is, where the participant preserves their stance and does not take a step during the execution of the test. A high percentage indicates good performance and; 5) percentage of directional control (DCL) (Błaszczyk et al., 2014; Suttanon et al., 2011; Suttanon et al., 2012a). Directional control is a comparison of sway towards the target to the amount of extraneous sway while leaning towards the target (Balance Manager System, 2005). A perfect DCL is equal to 100% LOS presented by a straight line from the centre to the target, while extraneous sway indicates low DCL and increased postural sway indicated by incongruence of the straight line. The individual who achieves these values can be considered to have a proprioception status within functional limits (Balance Manager System, 2005). Studies
found four directions: right and left directions, forward and backward measures are the most significant in terms of to which side the falls occur (Blake et al., 1988; Lord et al., 2003; Maki & Mcilroy, 1999; Rogers & Mille, 2003; Suttanon et al., 2011; Suttanon et al., 2012a).

Physiological Profile Approach

Figure 5.2 illustrated Physiological Profile Approach. The Physiologic Profile Approach was developed by Lord and colleagues (2003) from Neuroscience Research Australia, to evaluate risk of falling among older adults (Lord et al., 2003). The Physiologic Profile Approach measures five components, namely: (i) postural sway i.e sensorimotor function assessment; (ii) hand reaction time; (iii) quadriceps muscle strength; (iv) knee joint proprioception and (v) edge contrast sensitivity. All data were entered into the Physiologic Profile Approach web calculator (https://fbirc.neura.edu.au/fallscreen/) to be processed and analysed for the Physiologic Profile Approach index score. The Physiologic Profile Approach index score classifies falls risk as -2, -1, 0, 1 and 2 which indicate “very low risk of fall”, “low risk of fall, “mild risk of fall”, “moderate risk of fall”, and “marked risk of fall”, respectively (Lord et al., 2003).
Physiological Profile Approach measures the performance of 5 tasks in 2 positions (standing and sitting) (image courtesy from PPA kit Lord et al., 2003)

**Postural sway**

Sway-meter is a tool to measure displacement of postural sway of a body at the waist level (Lord et al., 2003). The test was performed under four conditions: Standing on floor with 1) EO; and 2) EC; standing on a foam rubber mat with 3) EO; and 4) EC (Lord et al., 2003). The foam rubber mat used was 40 cm x 40 cm x 7.5 cm thick. Maximal sway displacement (mm) in an antero-posterior and lateral direction were calculated (Lord et al., 2003). A small displacement indicates small sway and thus better performance. Data from the “EO standing on a rubber mat” test were entered into the web calculator for Physiologic Profile Approach index score (Lord et al., 2003).

**Hand reaction time**

This test measured reaction time of the hand in milliseconds (Lord et al., 2003). Participants had to press a switch with their finger on a hand-held electronic timer in reaction to seeing a light stimulus (Lord et al., 2003). A computer mouse was modified to be used as the response unit for the finger press task. The test was performed with the ceiling lamp dimmed to ensure the participant could easily detect the light stimulus. Participants sat with their hand resting on the mouse and were instructed to press the switch only when they saw the red light on the mouse come on. Five practice time trials
were given before the participants undertook the 10 actual test trials. In the 10 test trials, repeat and reaction times that were very slow (> 150-200ms above the usual time recorder during the practice trial) or notably fast (that is, if they pressed prior to the red light coming on and thus recorded a score < 150ms) were not recorded. The quicker the reaction time, the better the performance. All 10 readings were entered onto web calculator for the PPA index score.

**Quadriceps muscle strength**

Strength of the quadriceps muscle of the dominant (self-declared - the leg used to kick a ball) leg was measured with the participant sitting on a high chair with a strap comfortably placed around the leg 10 cm above the ankle joint (Lord et al., 2003). The angles of the hip and knee joints were placed at 90 degrees flexion (Lord et al., 2003). A spring gauge (scale) was attached to the strap and used to measure the strength in kilograms. Participants performed three trials, with a 10-20second rest period between each trial. The participant sat in a relaxed position and was asked to push as hard as they could without compensating with the other leg. If the test caused any pain, the test was stopped immediately. Three trials were undertaken and were recorded. A higher score indicates a better performance. The best score was entered into the web calculator for PPA index score.

**Knee joint proprioception**

Knee joint proprioception was measured using toes-matching task based on a project by De Domenico and McCloskey (De Domenico & McCloskey, 1987; Lord et al., 2003). Participants sat on a high chair with eyes closed and asked to align their big toes of each foot by extending the knees simultaneously. Errors in alignment, measured by a protractor which placed between the legs, were recorded (Lord et al., 2003). The protractor inscribed on vertical clear acrylic piece with a dimension of 60 cm x 60 cm x 1 cm. The errors in alignment of five trials in matching the two toes measured in degrees were recorded. A small error score indicates a good performance (Lord et al., 2003). All five scores were entered into the web calculator for the Physiologic Profile Approach score.
**Edge contrast sensitivity**

Visual acuity was assessed binocularly using a Melbourne Edge Test (logMAR chart) (Lord et al., 2003). This chart has 20 circular images containing edges with reducing contrast. The participant has to identify the orientation of the edges in the alignment of: 1) horizontal; 2) vertical; 3) 45 degrees left; and 4) 45 degrees right (Lord et al., 2003). During the instruction, the participant was provided with an answer card containing these 4 possible edge angles. Participants could wear their reading glasses if necessary. The score was based on the last circle that was correctly reported by the participant and the visual clarity of this circle was recorded in decibel units, where 1 dB = 10 log10 contrast (Lord et al., 2003). A higher score indicates better performance. The score was entered into the web calculator for the Physiologic Profile Approach index score (Lord et al., 2003; Suttanon et al., 2012a).

**Timed Up and Go test**

The TUG test (Podsiadlo & Richardson, 1991) was used to measure dynamic postural stability. This test timed the duration (in seconds) for the participant to stand up from a standard chair without an arm rest, walk 3 metres at their usual walking pace, turn 180°, returning to chair and sit down again in the chair (Podsiadlo & Richardson, 1991). Participants may use a walking device as necessary, but this use needs to be recorded and the device used in subsequent testing. The American Geriatrics Society / British Geriatrics Society have recommended the use of the TUG test as a screening tool to identify the risk of falling among older adults (Kenny et al., 2011). In healthy older adults, the variation of time completion was found to be from 9 seconds to 12.7 seconds (Moncada, 2011). For the purpose of this study, the cut off point of the TUG test used was 13.5 seconds which has 80% sensitivity and 100% specificity (Shumway-Cook et al., 2000). The shorter the time to complete the task the better the functional postural stability.

5.5 **Data cleaning: Screening, diagnosing and treating data abnormalities**

Data from the computerised posturography testing were saved as a portable document format file. All the raw data, including the demographic data, PPA and TUG test data,
were entered onto an Excel spreadsheet and were cleaned and categorised for statistical analysis.

To date, systematic guidelines for data cleaning are not available (Van den Broeck, Cunningham, Eeckels, & Herbst, 2005). For the current study, data cleaning followed the following three steps: 1) Screening; 2) Diagnostic; and 3) Treatment.

5.5.1 Screening

All data were tested for potential outliers by checking each of the values using the modified Thomson tau technique and redundancy. The emerging outliers were checked to ensure they were not due to mistakes during data entry by double checking with the original copy of the raw data. The redundant data if any were removed. Outliers were left unchanged if their true values were verified from checking the original data (Fergusson, Aaron, Guyatt, & Hébert, 2002) as my intention was to test the validity of tests.

5.5.2 Diagnostics

Missing data in the current study were due to participants being unable to complete a test due to safety concerns. In these instances, the test was stopped immediately and was noted as ‘unable to complete’.

5.5.3 Data treatment

Some adjustment of the data was required, mainly due to variations in age group, height and weight. These published recommended adjustments were only for the computerised posturography and the PPA data and are briefly explained below.

**Computerised posturography data treatment.**

There are recommendation adjustments for the computerised posturography global (in the time and frequency domain) data analysis (Duarte et al., (2010)) and structural (based on diffusion plots and sway-density plots) analysis (Baratto, Morasso, Re, & Spada, 2002; Collins & Luca, 1993; Duarte & Freitas, 2010; Duarte & Zatsiorsky,
There is no consensus, however, on how the data are supposed to be analysed and interpreted because petrographic data are complex and each of the authors make recommendations based on their concept of data analysis. For the purpose of this study, I used the global time domain which estimates the overall size of the sway pattern as discussed by Baratto et al. (2002) (Baratto et al., 2002). A sway pattern based on three tests (mCTSIB, sit to stand and step quick turn) is calculated, where a lower score indicates less sway. All scores in each variable were checked for completeness for the analysis (Loughran, Gatehouse, Kishore, & Swan, 2006). In the current study, the tests that had a composite score were excluded from the analysis due to some data sets having incomplete data because of participants being unable to finish some of the components of the test.

**Physiological Profile Approach data treatment**

To get the PPA falls risk score, the raw data of each item (sway, vision, proprioception, quadriceps muscle strength and reaction time) were entered into web-based software programme (https://www.neura.edu.au/). This software adjusts for age and sex, and computes the score. The computed scores were in a range from -2 to 4, indicating a low risk and a high risk of falling respectively (Lord et al., 2003).

For an individual score of the PPA, two variables were computed for correction, i.e., sway and quadriceps muscle strength. The correction was based on participant height for the sway variable and weight for quadriceps muscle strength variable. To compute the sway data from the PPA, all four measurements were taken for correction: 1) Anteroposterior sway whilst standing on form surface with EO and EC; and 2) Anteroposterior sway whilst standing on firm surface with EO and EC; 3) Latero-lateral sway whilst standing on form surface with EO and EC; and 4) Latero-lateral sway whilst standing on firm surface with EO and EC. The correction of anteroposterior and latero-lateral measure of sway score was calculated for body height, i.e., sway score x (average height of participants/participant’s height) (Lord & Castell, 1994; Lord, Rogers, Howland, & Fitzpatrick, 1999). Whereas for quadriceps muscle strength, the correction was based on height and weight: corrected strength = strength (Nm) / [weight (kg) x height/2 (m)] (Lord et al., 1999). The correction of the strength test was
based on the torque needed to maintain stability of the upright body acting as an inverted pendulum (Fitzpatrick, Taylor, & McCloskey, 1992).

**Timed Up and Go test data treatment**

There was no data treatment for the TUG test. The scoring data to two decimals were directly entered into the Excel spreadsheet.

### 5.6 Data analysis

The current study resulted in a small sample size causing the data to be skewed and therefore analysed using non-parametric tests. I used SPSS software for Windows version 23 (IBM Corporation, United State of America) for all data analysis. The tests used are explained below.

#### 5.6.1 Descriptive analysis of demographic characteristics

Descriptive analysis was used to calculate means, standard deviations and the range of the demographic data, and percentage was used for categorical data: age, sex, height, weight, ethnicity, education, MMSE score, diagnosis, corrective lenses, history of falling, number of medical conditions, number of medications and the usage of walking aids.

#### 5.6.2 Practicality: Descriptive analysis of loss of postural stability during the test

Missing data refer to the information that was missing during the research project and occurring at any level: recruitment, data collection, or during data preparation for the analysis (Hardy, Allore, & Studenski, 2009; Rousseau, Simon, Bertrand, & Hachey, 2012). There were three types of mechanisms for missing data (Hardy et al., 2009; Heitjan & Basu, 1996; Rousseau et al., 2012): 1) missing completely at random is “if the likelihood of being missing is not related to either the value of the missing variable or to the values of any other variables in the data set” ((Hardy et al., 2009), p. 14); 2) missing at random is “if the likelihood of missing data can be completely explained by other variables in the analysis” ((Hardy et al., 2009), p. 14); and 3) missing not at random is “if the missing values are not randomly distributed across participants, and
the probability of being missing cannot be predicted from the other variables” ((Hardy et al., 2009), p. 14). In this current study, one classification of missing data occurred, ‘missing completely at random’ (n = 1) as this was due to the equipment failing to work correctly.

If drop-out is dependent on unknown or unmeasured parameters, the sample size is reduced and the analysis will ignore any observed score of postural stability components in the excluded participants (Burton, Billingham, & Bryan, 2007). In this study, one participant (P6) was excluded from the analysis for all the tests that involved the PPA because he was only able to complete less than half (< 50%) of the components of the PPA test (Table 5.2).

5.6.3 Descriptive analysis to compare demographic characteristics and postural stability variables between the non-faller and the faller

Descriptive analysis was conducted to compare median and inter quartile range for age, height, weight, and MMSE and postural stability variables between those classified as “non-fallers” and those as “fallers”. The significant differences of all measurements between these two groups were conducted using Mann Whitney U test for 2 independent groups and the significant level was set at p < 0.05.

5.6.4 Test of concurrent validity

Concurrent validity between the PPA, the TUG and the computerised posturography variables was calculated using the Spearman rank order correlation as all values violated the assumption of normality and linearity. Variables from each of the tests that had similar properties were correlated, as opposed to total scores.

The strength of correlation coefficient was based on the criteria by Portney and Watkins (2015), namely, $r_s \geq 0.75$ – good to excellent relationship, $0.50 - 0.75$ moderate to good, $0.25$ to $0.50$ – fair, and $< 0.25$ – little or no relationship (Portney & Watkins, 2000; Portney & Watkins, 2015). The significant level was set at $p < 0.05$. 

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For the purpose of vision evaluation in the EO and EC condition, Romberg ratio (on firm and form surface) was calculated by dividing the score of eyes closed with EO (Fujita et al., 2005) for both PPA and computerised posturography sway. The substantial increase, of sway under EC relative to EO condition, is indicative of impairment of the dominant somatosensory input. A value exceeding 1.0 would indicate a greater amount of postural sway during EC (Tjernström, Björklund, & Malmström, 2015).

5.6.5 Test of sensitivity, specificity and ROC curve

The probability of a fall was calculated with the likelihood ratios (LRs) at the specified cut point. A positive LR (LR+) was calculated as the sensitivity (the fraction of true positives) divided by (1−specificity) (Altman & Bland, 1994). A negative LR (LR-) was calculated as (1−sensitivity) divided by the specificity (the fraction of true negatives) (Altman & Bland, 1994). For the PPA, the cut off point is 2; >2 have high risk of falling, <2 have low risk of falling (Lord et al., 2003), and for TUG Go test the cut off point is 13.5 seconds; >13.5 seconds have high risk, <13.5 seconds have low risk of falling (Shumway-Cook et al., 2000).

Receiver operating curves with the area under the curve (AUC) analysis were derived to determine the optimal cut point values of the association between the TUG, the PPA and self-reported falls. The AUC is the probability that the older adult, with self-reported memory loss who is a “faller”, will be correctly identified by the test, given that two randomly selected older adults with memory loss are selected, one who is a faller and another who is a non-faller. The interpretation of AUC analysis were: 1) a result of 0.5 indicates the association due to chance; 2) 0.5 to 0.7 indicates low accuracy; 3) 0.9 to 1.0 indicates high accuracy; and 4) 1.0 indicates a perfect test (Akobeng, 2007; Greiner, Pfeiffer, & Smith, 2000).

5.7 Results

The results of these psychometric studies are reported in seven sections, namely: 1) Participants; 2) Practicality of the tests; 3) Comparison of mean and standard deviation values of all postural stability variables; 4) Comparison of median and interquartile
range of all the postural stability variables between “non-fallers” and “fallers”; 5) Concurrent validity results; 6) Sensitivity and specificity of the TUG test and the PPA; and 7) Diagnostic accuracy of PPA and TUG test.

5.7.1 Participants

Table 5.1 illustrates the demographic data for the 13 participants included in this study. Sixteen older adults volunteered to participate, but three participants were excluded due to the severity of their cognitive impairment, leaving 13 participants (7 male, 5 female) eligible for inclusion. Included participants had a mean (SD) age of 80 (8) years (range 71 - 94 years) and a mean (SD) Mini-Mental State Examination score of 19 (9) (range 14 – 28). Ten participants were recruited from a day care programme that was specifically designed for older adults with dementia and three participants via the local Alzheimer’s Society newsletter. Three participants had known diagnoses of dementia (one with Alzheimer’s disease, two with fronto-temporal lobe dementia). A history of falls in the previous year was self-reported by four participants and confirmed by their support person. The medical history for each participant was based on self-report: n=1 (8%) hypertension, n = 4 (31%) heart disease, n = 2 (15%) lung disease, n = 2 (15%) depression, n = 1 (71%) diabetes, n = 5 (33%) musculoskeletal and n = 1 (8%) history of stroke. Four participants (31%) were taking no medications and nine (69%) were taking one or more medications. One participant used a walking stick during the TUG, walk across and step quick turn tests. One participant could not perform the walk across and step quick turn tests due to failure of the equipment. One participant did not complete the PPA as she was too anxious about the testing.
Table 5.1 Demographics and health status characteristics of participants (n = 13)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age years</td>
<td>80 (8)</td>
<td>71 - 94</td>
</tr>
<tr>
<td>Male n, %</td>
<td>7, 54</td>
<td></td>
</tr>
<tr>
<td>Height, m</td>
<td>1.6 (1.6)</td>
<td>1.43 - 1.9</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>73.9 (13.0)</td>
<td>41.0 – 93.0</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>European NZ, %</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Other, %</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School, %</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Tertiary diploma/ degree, %</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Other, %</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>MMSEa</td>
<td>19 (9)</td>
<td>14 - 28</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Known to have dementia n, %</td>
<td>3, 23</td>
<td></td>
</tr>
<tr>
<td>Unable to confirm diagnosis n,%</td>
<td>10, 77</td>
<td></td>
</tr>
<tr>
<td>Corrective lenses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bifocal</td>
<td>11, 85</td>
<td></td>
</tr>
<tr>
<td>No visual correction</td>
<td>2, 15</td>
<td></td>
</tr>
<tr>
<td>History of fall:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No fall n, %</td>
<td>9, 69</td>
<td></td>
</tr>
<tr>
<td>One time fall n, %</td>
<td>4, 31</td>
<td></td>
</tr>
<tr>
<td>Number of medical conditionsb n, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>4, 31</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4, 31</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2, 15</td>
<td></td>
</tr>
<tr>
<td>≥3</td>
<td>3, 23</td>
<td></td>
</tr>
<tr>
<td>No of medications</td>
<td></td>
<td>0 - 4</td>
</tr>
<tr>
<td>Use of walking aids n, (%)</td>
<td>1, 8</td>
<td></td>
</tr>
</tbody>
</table>

Notes. MMSE, Mini-Mental State Examination; SD, standard deviation; TUG, Timed Up and Go test.
a n = 11, 2 participants did not have recent MMSE scores.
b Medical conditions included: hypertension, heart disease, lung disease, depression, diabetes, musculoskeletal and history of stroke.
All values are mean (standard deviation) or as otherwise indicated.

5.7.2 Practicality: Loss of postural stability during the test

Table 5.2 shows the distribution of the completeness of each test component. Most participants could perform all tests with no problems. One participant (P6) however requested the testing to stop because they felt unsafe, and 5 participants (P4, P5, P8, P10 and P13) (age mean 83 (range 74-94); Mini-Mental State Examination mean 20 (range 16-22); n = 2 had history of fall; n = 2 with known dementia) were not be able to complete the mCTSIB test with EC on the foam surface. For one (8%) participant, the
computer was unable to compute the score on the step quick turn to right test. One (8%) participant, due to the failure of the equipment to run the test, was unable to complete the walk across test. Six (46%) participants (P1, P3, P4, P5, P8 and P11) (age mean 78 (range 71-94); Mini-Mental State Examination mean 21 (14-27) range; n = 3 had history of fall; n = 1 with known dementia) were not able to complete the limit of stability test (n = 5, forward; n = 5, right forward; n = 4, right; n = 2, right backward; n = 4, backward; n = 4, left backward, n = 2, left; n = 3, left forward) on the computerised posturography. Fifteen items (23%) of the total 65 items that should have been collected were missing from computerised posturography, compared to one item (4%) of the total 26 items from the clinical measures (the TUG test and the PPA).

There were no safety incidents reported during or after the tests.
<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Sex</th>
<th>MMSE</th>
<th>Diagnosis</th>
<th>Fall</th>
<th>Med</th>
<th>PPA</th>
<th>TUG</th>
<th>mCTSIB</th>
<th>SQT</th>
<th>STS</th>
<th>WA</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>71</td>
<td>M</td>
<td>14</td>
<td>DNK</td>
<td>Yes</td>
<td>0</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>P2</td>
<td>79</td>
<td>M</td>
<td>28</td>
<td>DNK</td>
<td>No</td>
<td>1</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>X</td>
<td>√</td>
<td>MCAR</td>
<td>X</td>
</tr>
<tr>
<td>P3</td>
<td>76</td>
<td>M</td>
<td>27</td>
<td>DNK</td>
<td>Yes</td>
<td>0</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P4</td>
<td>74</td>
<td>M</td>
<td>21</td>
<td>AD</td>
<td>No</td>
<td>2</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>X</td>
<td>√</td>
<td>MCAR</td>
<td>X</td>
</tr>
<tr>
<td>P5</td>
<td>91</td>
<td>F</td>
<td>22</td>
<td>DNK</td>
<td>Yes</td>
<td>0</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P6</td>
<td>71</td>
<td>F</td>
<td>.</td>
<td>DNK</td>
<td>Yes</td>
<td>1</td>
<td>√</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>√</td>
<td>√</td>
<td>R</td>
</tr>
<tr>
<td>P7</td>
<td>85</td>
<td>M</td>
<td>25</td>
<td>DNK</td>
<td>No</td>
<td>1</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P8</td>
<td>78</td>
<td>F</td>
<td>22</td>
<td>DNK</td>
<td>No</td>
<td>3</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P9</td>
<td>82</td>
<td>M</td>
<td>24</td>
<td>FTLD</td>
<td>No</td>
<td>4</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P10</td>
<td>94</td>
<td>F</td>
<td>.</td>
<td>DNK</td>
<td>No</td>
<td>2</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P11</td>
<td>75</td>
<td>F</td>
<td>21</td>
<td>DNK</td>
<td>No</td>
<td>1</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P12</td>
<td>90</td>
<td>F</td>
<td>20</td>
<td>DNK</td>
<td>No</td>
<td>0</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>P13</td>
<td>78</td>
<td>M</td>
<td>16</td>
<td>Dementia</td>
<td>No</td>
<td>3</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
</tbody>
</table>

**Table 5.2 Number and percentage of participants completing each of the variables.**

<table>
<thead>
<tr>
<th>N=13</th>
<th>Age</th>
<th>Sex</th>
<th>MMSE</th>
<th>Diagnosis</th>
<th>Fall</th>
<th>Med</th>
<th>PPA</th>
<th>TUG</th>
<th>mCTSIB</th>
<th>SQT</th>
<th>STS</th>
<th>WA</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>n, %</td>
<td>3, 23%</td>
<td>12, 92%</td>
<td>13, 100%</td>
<td>7, 54%</td>
<td>11, 85%</td>
<td>13, 100%</td>
<td>12, 92%</td>
<td>6, 46%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes.** DNK, diagnosis not known; FTLD, Frontal Temporal Lobe Dementia; LOS, limit of stability; MCAR, data missing completely at random; mCTSIB, modified Clinical Test of Sensory Interaction on Balance; PPA, Physiological Profile Approach; R, refused; SQT, step quick turn; STS, sit to stand; TUG, Timed Up and Go test; WA, walk across.

√ = complete test component; X = incomplete test component

% = percentage completeness each of test component

*partial data available (item non-response (Schafer, 1999))
5.7.3 Comparison of the median and the interquartile range of demographic variables between non-fallers and fallers

Table 5.3 illustrates the comparison of the median and the interquartile range of the characteristics of participants between the non-fallers and fallers and Table D.3 (see Appendix D) illustrates the comparison of descriptive analysis of all variables of postural stability measurements.

There was no significant difference (p > 0.05) between both groups for demographic characteristics: age, sex, height, weight and MMSE. The Mann Whitney test found non-significant differences (p < 0.05) across all variables of postural stability between non-fallers and fallers groups except for one variable; turn to right during step quick turn test ($z = -2.046$, p = 0.04). Limit of stability has been omitted from the analysis due to not enough data for comparison to be made. Nearly half of the participants (6/13) unable to complete the limit of stability test.

Table 5.3 Characteristics of participants comparing the non-fallers with the and fallers in the group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Fall status</th>
<th>n</th>
<th>Median</th>
<th>Interquartile range</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, year</td>
<td>Non-faller</td>
<td>9</td>
<td>79</td>
<td>11</td>
<td>-1.238</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Faller</td>
<td>4</td>
<td>74</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height, meter</td>
<td>Non-faller</td>
<td>9</td>
<td>1.66</td>
<td>0.21</td>
<td>-0.077</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Faller</td>
<td>4</td>
<td>1.63</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight, kg</td>
<td>Non-faller</td>
<td>9</td>
<td>78</td>
<td>18.5</td>
<td>-0.464</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>Faller</td>
<td>4</td>
<td>72</td>
<td>11.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE</td>
<td>Non-faller</td>
<td>8</td>
<td>21</td>
<td>7</td>
<td>-0.103</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Faller</td>
<td>3</td>
<td>18</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes. MMSE, mini mental state examination.
Significant at p < 0.05 level.
5.7.4 Concurrent validity

Table 5.4 - Table 5.8 illustrate the results of the correlation coefficients of the PPA and the TUG test against variables from computerised posturography, namely, mCTSIB, sit to stand, step quick turn and walk across tests.

Concurrent validity of Physiological Profile Approach

To assess the concurrent validity of the PPA, the performance of each item (sway, vision, proprioception, quadriceps muscle strength and reaction time) on the test was compared with tasks of a similar nature performed using computerised posturography. Table 5.4 - Table 5.8 report these data. Spearman’s rho indicated the presence of moderate to good positive correlation between muscle strength (PPA) and the rising index (computerised posturography) \( r_s = 0.699, p = 0.01, n = 12 \), mediolateral sway during eyes open standing on foam (PPA) and sway velocity during eyes open standing on foam surface (computerised posturography) \( r_s = 0.604, p = 0.04, n = 12 \). There were good negative correlations between anteroposterior sway during eyes closed standing on foam (PPA) and sway velocity during standing on foam with eyes open (computerised posturography) \( r_s = -0.745, p = 0.01, n = 12 \) and Romberg ratio between PPA and computerised posturography \( r_s = -0.698, p = 0.02, n = 12 \). The others variables did not significantly correlate \( p > 0.05 \).
Table 5.4 Spearman rank correlation ($r_s$) between sway (Physiological Profile Approach) and sway in anteroposterior and mediolateral direction (mCTSIB from computerised posturography).

<table>
<thead>
<tr>
<th>PPA</th>
<th>mCTSIB</th>
<th>Firm surface</th>
<th>Foam surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EO sway AP</td>
<td>EC sway AP</td>
</tr>
<tr>
<td>Firm Surface</td>
<td></td>
<td>$r_s$</td>
<td>$p$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.320</td>
<td>-0.176</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.31</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>EO sway ML</td>
<td></td>
<td>0.386</td>
<td>0.302</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.22</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>EC sway AP</td>
<td></td>
<td>-0.484</td>
<td>-0.043</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.11</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
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<td>12</td>
<td>12</td>
</tr>
<tr>
<td>EC sway ML</td>
<td></td>
<td>0.040</td>
<td>0.107</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.90</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Foam Surface</td>
<td></td>
<td>0.018</td>
<td>-0.438</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.96</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>EO sway ML</td>
<td></td>
<td>0.604*</td>
<td>0.463</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.04</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>EC sway AP</td>
<td></td>
<td>-0.327</td>
<td>-0.219</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.30</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>EC sway ML</td>
<td></td>
<td>-0.104</td>
<td>-0.046</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.75</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Notes. AP, anteroposterior; EO, eyes open; EC, eyes closed; mCTSIB, modified clinical test of sensory interaction on balance; ML, mediolateral; PPA, Physiological Profile Approach.

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Table 5.5 Spearman rank correlation ($r_s$) between visual contrast sensitivity and Romberg ratio (firm and foam surface)

<table>
<thead>
<tr>
<th>PPA</th>
<th>Visual contrast sensitivity</th>
<th>Romberg ratio (mCTSIB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r_s$</td>
<td>0.330</td>
</tr>
<tr>
<td></td>
<td>$p$</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>$n$</td>
<td>12</td>
</tr>
<tr>
<td>Romberg ratio (firm surface) $r_s$</td>
<td>0.135</td>
<td>-0.113</td>
</tr>
<tr>
<td></td>
<td>$p$</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>$n$</td>
<td>12</td>
</tr>
<tr>
<td>Romberg ratio (foam surface) $r_s$</td>
<td>0.191</td>
<td>-0.698*</td>
</tr>
<tr>
<td></td>
<td>$p$</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>$n$</td>
<td>12</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed).

Notes. mCTSIB, modified clinical test of sensory interaction on balance; PPA, Physiological Profile Approach.

Table 5.6 Spearman rank correlation ($r_s$) between hand reaction time (Physiological Profile Approach) and limit of stability (computerised posturography)

<table>
<thead>
<tr>
<th>PPA</th>
<th>Limit of stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand reaction $r_s$</td>
<td>RTL</td>
</tr>
<tr>
<td></td>
<td>$r_s$</td>
</tr>
<tr>
<td></td>
<td>$p$</td>
</tr>
<tr>
<td></td>
<td>$n$</td>
</tr>
</tbody>
</table>

Notes. MVR, movement velocity right; MVL, movement velocity left; PPA, Physiological Profile Approach; RTL, reaction time left; RTR, reaction time right.

Differences in number of participants due to the number of participants who completed the test.
Table 5.7 Spearman rank correlation ($r_s$) between muscle strength and proprioception (Physiological Profile Approach) and sit to stand measures (computerised posturography)

<table>
<thead>
<tr>
<th>PPA</th>
<th>Sit to stand</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WTT</td>
<td>RI</td>
<td>SV</td>
<td>LRWS</td>
<td></td>
</tr>
<tr>
<td>Muscle strength</td>
<td>$r_s$</td>
<td>0.554</td>
<td>0.699*</td>
<td>-0.323</td>
<td>-0.189</td>
</tr>
<tr>
<td></td>
<td>$p$</td>
<td>0.06</td>
<td>0.01</td>
<td>0.31</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>$n$</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Proprioception</td>
<td>$r_s$</td>
<td>-0.055</td>
<td>0.215</td>
<td>-0.135</td>
<td>0.315</td>
</tr>
<tr>
<td></td>
<td>$p$</td>
<td>0.87</td>
<td>0.50</td>
<td>0.68</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>$n$</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed).

Notes. PPA, Physiological Profile Approach; WTT, weight transfer time; RI, rising index; SV, sway velocity; LRWS, left right weight symmetry.

Concurrent validity of Timed Up and Go test

Similarly, to assess the concurrent validity of the TUG test, performance of the test was compared with tasks of a similar nature performed using computerised posturography. Table 5.8 reports the results of concurrent validity between TUG test and step quick, sit to stand and walk across tests. Moderate to good positive correlations were found between the TUG and the step quick turn time turn to left (computerised posturography) ($r_s = 0.548$, $p = 0.042$, $n = 12$) and step quick turn sway to left (computerised posturography) ($r_s = 0.646$, $p = 0.017$, $n = 11$). Good to excellent negative correlation was found between the TUG test and rising index (computerised posturography) ($r_s = -0.719$, $p = 0.006$, $n = 13$). The others variables did not significantly correlate ($p > 0.05$).
Table 5.8 Spearman rank correlation ($r_s$) between Timed Up and Go test and step quick, sit to stand and walk across tests (computerised posturography).

<table>
<thead>
<tr>
<th></th>
<th>Step quick turn</th>
<th>Sit to stand</th>
<th>Walk across</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TTL</td>
<td>TTR</td>
<td>TSL</td>
</tr>
<tr>
<td>Timed Up and Go</td>
<td>$r_s$</td>
<td>0.584*</td>
<td>0.245</td>
</tr>
<tr>
<td></td>
<td>$p$</td>
<td>0.04</td>
<td>0.47</td>
</tr>
<tr>
<td>$n$</td>
<td>12</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

Notes. TTL, turn time left; TTR, turn time right; TSL, turn sway left; TSR, turn sway right; WTT, weight transfer time; RI, rising index; SV, sway velocity; LRWS, left right weight symmetry; SW, walk step width; SL, step length, WS, walk speed; LRS, left right walk symmetry.

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).
5.7.5 Sensitivity and specificity: discrimination of the Physiological Profile Approach and the Timed Up and Go performance between fallers and non-fallers

Table 5.9 and Table 5.10 illustrate the 2x2 Matrix for fall risk evaluated in the TUG and the PPA, and the sensitivity, specificity and likelihood ratio of TUG and the PPA calculated with data from Table 5.9.

Table 5.9 Display derived from the 2x2 Matrix for fall risk evaluated in Timed Up and Go test and Physiological Profile Approach

<table>
<thead>
<tr>
<th>Test</th>
<th>n</th>
<th>True positive</th>
<th>False positive</th>
<th>True negative</th>
<th>False negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG</td>
<td>13</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>PPA</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Notes. Discrepancy in sample size due to the numbers of completed test by participants. One participant did not complete the Physiological Profile Approach, thus was excluded from the analysis.

Table 5.10 The sensitivity, specificity and likelihood ratio of Timed Up and Go and the Physiological Profile Approach calculated with data from Table 5.9

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity (n = number with condition)</th>
<th>Specificity (n = number without condition)</th>
<th>Likelihood ratio positive (95% CI)</th>
<th>Likelihood ratio negative (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG Fall risk</td>
<td>0.75 (n=4)</td>
<td>0.67 (n=9)</td>
<td>2.25 (0.76, 6.65)</td>
<td>0.76 (0.07, 2.18)</td>
</tr>
<tr>
<td>PPA Fall risk</td>
<td>0.33 (n=3)</td>
<td>0.89 (n=9)</td>
<td>3 (0.26,34,58)</td>
<td>0.75 (0.33,1.73)</td>
</tr>
</tbody>
</table>

Notes. Discrepancy in sample size due to the numbers of completed tests by participants. One participant did not complete the Physiological Profile Approach.

5.7.6 Diagnostic accuracy of Physiological Profile Approach and Timed Up and Go test

Table 5.11 and Table 5.12 illustrate the screening characteristics of the PPA and the TUG test for reported falls in persons with self-reported memory loss respectively. 

Figure 5.3 and Figure 5.4 show the receiver operator curves (ROC) for the PPA and the TUG test for self-reported falls in persons with self-reported memory loss respectively.
Diagnostic accuracy of the Physiological Profile Approach

Table 5.11 illustrates the screening characteristics of the PPA for reported falls in persons who self-reported memory loss for cut off scores of -1 to 3 and Figure 5.3 illustrates the receiver operator curve (ROC) for the PPA for self-reported falls in persons who self-reported memory loss. Of the 12 participants in this study, three had a history of falling in the past year. Ten participants had no falls in the past year. Participants’ PPA scores were compared with their history of known falls as shown in Table 5.3. The PPA test produced 75% accuracy, low sensitivity 33% and high specificity 89%. The ROC curve cut off score of 2 achieved best specificity to discriminate between fallers and non-fallers.

Table 5.11 The screening characteristics of the Physiological Profile Approach for reported falls in person with self-reported memory loss

<table>
<thead>
<tr>
<th>PPA cut off</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>True positive</th>
<th>False positive</th>
<th>True negative</th>
<th>False negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>100%</td>
<td>0</td>
<td>3</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>66.67%</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>33.33%</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>33.33%</td>
<td>88.89%</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>33.33%</td>
<td>100%</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

Notes. PPA, Physiological Profile Approach.
Figure 5.3 The receiver operator curve (ROC) for the Physiological Profile Approach for self-reported falls in persons with mild to moderate cognitive impairment.

Diagnostic accuracy of the Timed Up and Go test

Table 5.12 illustrates the screening characteristics of the TUG test for reported falls in persons with self-reported memory loss from 8 seconds to 15 seconds and Figure 5.4 illustrates the receiver operator curve (ROC) for the TUG test for self-reported falls in persons with self-reported memory loss. Screening results for the full sample (n = 13) were compared with those with a known history of falls (n = 4). Sensitivity and specificity values for TUG test categories, from 8 seconds to 15 seconds, to classify faller and non-faller are reported in Table 5.12. The cut off of 8 seconds showed the highest degree of sensitivity. There was a 39% increase in sensitivity for 8 seconds cut off compared to a cut off of 15 seconds. A cut off of 13 seconds improved specificity by 66.67% with 14% drop in sensitivity for classifying the faller. Thus, the cut off of 13 seconds achieved best sensitivity and specificity to discriminate between fallers and non-fallers.
Table 5.12 The screening characteristics of the Timed Up and Go test for reported falls in persons with self-reported memory loss from 8 seconds to 15 seconds (n = 13)

<table>
<thead>
<tr>
<th>TUG cut off</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>True positive</th>
<th>False positive</th>
<th>True negative</th>
<th>False negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>89%</td>
<td>11.11%</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>75%</td>
<td>22.22%</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>75%</td>
<td>22.22%</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>75%</td>
<td>55%</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>75%</td>
<td>66.67%</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>75%</td>
<td>77.78%</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>50%</td>
<td>77.78%</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>50%</td>
<td>88.89%</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

*Notes.* TUG, Timed Up and Go test.

**Figure 5.4** The receiver operator curve (ROC) for the Timed Up and Go test for self-reported falls by persons with mild to moderate cognitive impairment.
5.8 Discussion

I recruited and tested 13 older adults aged 71 to 94 years old, with self-reported memory loss. Although I wished to recruit only participants with confirmed diagnoses of Alzheimer’s disease, only three participants had confirmed diagnosis of Alzheimer’s disease, while the diagnoses of other participants remained unconfirmed. This is the most likely reason for a low falls rate. Later in this section I will discuss the challenges presented in recruiting older adults with mild to moderate cognitive impairment due to dementia.

The current study wished to identify robust outcome measures to assess postural stability and falls risk in a community setting (i.e., outside a laboratory setting). The first aim of this study was to evaluate the concurrent validity of the PPA, the TUG test and computerised posturography in older adults with self-reported memory impairment. Four pairs of variables were correlated and concurrent validity was demonstrated for the PPA test item “quadriceps muscle strength” with rising index in sit to stand test \( r_s 0.699 (p = 0.01) \) and the TUG test had moderate to excellent correlation with rising index in the sit to stand test \( r_s -0.719 (p = 0.06) \) and turn time to left \( r_s 0.584 (p = 0.04) \) and turn sway to left \( r_s,0.646 (p =0.02) \) in the step quick turn test, as measured by computerised posturography. These findings indicate that although some tests performed on the computerised posturography were similar to the PPA test items and the TUG tests, not all were, and thus both clinical tests may be required to evaluate postural stability in older adult with self-reported memory loss in a clinical setting.

The second aim of this current study was to evaluate the ability of the PPA and the TUG test to distinguish between fallers and non-fallers in older adults with self-reported memory impairment. It appears only the TUG test was sufficiently sensitive to assess risk of falls in older adults with memory loss with a cut off point of 13 seconds. Current literature reports that older adults with mild cognitive impairment fall frequently (Alexander et al., 1995; Allan et al., 2009; Ballard et al., 1999; Bassiony et al., 2004; Borges et al., 2015; Carvalho & Coutinho, 2002; Chong et al., 1999; Horikawa et al., 2005; Imamura et al., 2000; Pettersson et al., 2002; Salvà et al., 2012; Suttonan et al., 2013; Tinetti et al., 1988; Whitney et al., 2005; Yasumura et al., 1994).
suggesting that determining as early as possible the risk of falling is an important consideration in an optimal assessment of such an individual. Moreover, the TUG test is a simple test that can easily be used in a community setting. There was a suggestion to optimise the assessment of risk of fall by using both the TUG test and the PPA (Whitney et al., 2005). However, in our current study, the PPA appears insufficiently sensitive in assessing risk of fall. Further discussion of these results, aim one and aim two, follows below (see 5.9.1 and 5.9.2).

5.8.1 Concurrent validity

This study correlated variables that measure similar constructs between items from the PPA and the TUG test with items from computerised posturography. Due to recruitment difficulties (to be discussed later), participants were selected based on self-report of memory loss as opposed to confirmed diagnostic criteria. Subsequent testing of participants with the MMSE however, confirmed that eight participants did indeed have mild to moderate cognitive impairment (mean (SD) 20 (3), range 14-24). Thus the findings of this study, whilst not reflecting specific diagnostic conditions (such as Alzheimer’s disease or specific dementias), are representative for older adults with mild to moderate cognitive impairment. However, the indication of mild to moderate of cognitive impairment was solely from the MMSE. A previous review reported that this has high sensitivity (87% sensitivity) to measure cognitive impairment among older adults with dementia (Folstein, Anthony, Parhad, Duffy, & Gruenberg, 1985; Tombaugh & McIntyre, 1992). However, this finding was reported following study of participants who were in residential care, in hospital or presenting at memory/dementia clinics and may thus have moderate to severe cognitive impairment, i.e., a different level to those recruited in my study.

This study demonstrated that participants, who had stronger quadriceps muscles and were faster at completing the TUG test, have higher force generation from their lower legs when standing up (as measured by computerised posturography). Previous studies have evaluated the relationship of muscle strength and the sit to stand task in older adults (Lord, Murray, Chapman, Munro, & Tiedemann, 2002; Mun-San Kwan, Lin, Chen, Close, & Lord, 2011; Schenkman, Hughes, Samsa, & Studenski, 1996; Skelton, 185
Greig, Davies, & Young, 1994). For instance, in a study by Mun-San Kwan et al. (2011) these researchers examined the physiological factors which influence performance of the TUG test (Mun-San Kwan et al., 2011). The test was conducted among 280 community dwelling older adults aged 65 years and above (Mun-San Kwan et al., 2011). The study found that quadriceps muscle strength significantly influences ($p < 0.001$, $r^2 = 0.231$) the performance of the TUG test (Mun-San Kwan et al., 2011). In this context, only the quadriceps muscle was evaluated. Sit to stand is a common daily living activity that requires a person to change posture by flexing the trunk, lifting up the buttocks off from the seat of a chair and extending the lower extremity (Millington, Myklebust, & Shambes, 1992). Thus, adequate strength of specific muscles is required to successfully perform sit to stand. It was shown that there is about 1-2% per annum decline in muscle strength even among healthy older adults aged 70 years and above (Skelton, Greig, Davies, & Young, 1994). Strength of the ankle muscles showed greatest decline that could lead to falls (Whipple, Wolfson, & Amerman, 1987). In older adults with dementia, more strategies to stand up, such as pushing through the armrest during the extension phase, have been described (Dolecka, Ownsworth, & Kuys, 2015). Using the arms to assist in standing up may be as a compensation for weakness of the lower limb muscles to extend the knee and hip for successful upright stance. It has also been reported that older adults take a longer time to stabilise the body before they can stand up from a seated position (Corrigan & Bohannon, 2001) and thus time taken to perform the TUG test maybe compromised. Further, slower standing up in the older adult has been associated with an increased risk of falling (Campbell, Borrie, & Spears, 1989; Nevitt & Cummings, 1989; Tinetti, 1986). The quadriceps muscle is thus important for the generation of force during the initialisation of the extension phase of sit to stand (Corrigan & Bohannon, 2001; Miyoshi et al., 2005) and, thus, weakness of this muscle could impact postural stability (Carter et al., 2002) and recovery from postural instability (Karamanidis, Arampatzis, & Mademli, 2008).

Turning plays a role in many upright physical activities. Turning requires asymmetrical limb movement (Dite & Temple, 2002; Orendurff et al., 2006). It is performed by changes in stride and functional limb length on the inside limb and the outside limb.
During turning and through changes in the execution of knee flexion-extension and ankle dorsi-plantarflexion, the inside limb is theorised to be functionally shorter than the outside limb (Dite & Temple, 2002; Orendurff et al., 2006). The inside foot is subject to a prolonged stance phase and a 10% increase in vertical force in the posteromedial section of the foot compared to straight-line walking (Peyer, Brassey, Rose, & Sellers, 2017). The centre of gravity changes during turning, starting with the repositioning of the head, then turning the trunk and changing foot placement. The present study found a correlation between the TUG test with the time taken and the sway measured during a turning task measured by computerised posturography. However, this correlation was only significant for turning to the left for the latter test. For the TUG test, the researcher did not specify which direction the participant must turn to. Mostly likely the correlation with only the left turn test is due leg dominance, unfortunately these data were not collected from participants. Previous studies have found that during turning in the TUG test, older adults at high risk of falling will take additional steps (Dite & Temple, 2002), decrease velocity (Courtine & Schieppati, 2003; Orendurff et al., 2006; Turcato et al., 2015) and take longer (Wall et al., 2000); all strategies designed to increase stability. However, these three studies did not mention if the TUG test was tested to turn to the dominant or non-dominant leg. It may be useful information in future studies to time the TUG test with participants turning to both sides. This is an area of further evaluation. I hypothesise that, in my study, during turning to left, the non-dominant leg may have been the inside leg, and so that during the stance phase, the non-dominant leg was only able to weight bear for a short duration and in consequence more steps were taken and this increased the time of completion of TUG test.

The other five components of variables failed to reach a statistically significant correlation, namely: 1) PPA (sway measure) versus mCTSIB; 2) PPA (Hand reaction time) versus limit of stability; 3) PPA (contrast sensitivity) versus Romberg ratio; 4) PPA (proprioception) versus sit to stand; and 5) TUG versus walk across. There may be a few possible reasons for these findings.
First, for the correlation between sway items between the PPA and the modified clinical test of sensory interaction on balance, the main tests that challenged participants were those of upright standing on the foam with eyes open and eyes closed conditions. The difference between the tests could be because of the differing density of the foam used to stand on. I hypothesise that the foam used in the computerised posturography had higher elasticity, thus caused more sway. Patel et al. (2008) reported on the elasticity of the foam used in their test (with foam categorised as by their elastic modulus firm foam, medium foam and soft foam) and found that there was more variance in torque when standing on more elastic foam (Patel, Fransson, Lush, & Gomez, 2008). Standing on a foam (high elasticity) surface is thought to exaggerate postural stability sway by reducing the reliability of somatosensory input from cutaneous mechanoreceptors on the base of feet and by changing the efficiency of ankle torque (Perry, McIlroy, & Maki, 2000; Wu & Chiang, 1997). The amount of compression explains this theory; if the compression of the foam surface which has low elasticity was large, participants would be able to feel some of the hard surface (i.e., floor) beneath the foam, thus the accuracy of sensory information from the mechanoreceptors on the base of feet may increase (Patel et al., 2008), therefore stability is increased. Even though Patel’s study was conducted among healthy adults aged 19 to 43 (Patel et al., 2008), it suggests that different foams used might give different results in the performance of postural stability. However, I did not measure the density or thickness of the foam in used both outcome measures, thus I acknowledge this a limitation of the methodology of this current study.

The precision limitation of sway measure by the PPA could be another reason for the lack of correlation, as measuring the distance of trajectory of the sway measure is challenging and introduces error. This is done “manually” using the graph papers provided. It is now recommended (after I had collected my data) to use the new software of the PPA that directly digitally measures the distance during the test (https://www.neura.edu.au/, Prince of Wales Medical Research Institute, Randwick, Sydney, NSW, Australia). My finding in this regard is, however, not in line with that of a previous study that measured the validity of measuring postural sway with the swaymeter device of the PPA compared to that measured by a force plate (Sturnieks,
Arnold, & Lord, 2011). Sturnieks et al. (2011) found moderate to good correlations ($r_s = 0.560$-$0.865$) between the swaymeter and the force plate sway: standing on firm surface with EO and EC; standing on foam surface with EO and EC (Sturnieks et al., 2011). This study suggests that the swaymeter has good agreement with the force plate COP measures for anterior-posterior ($r_s > 0.743$) and medio-lateral displacement ($r_s > 0.692$). However, Sturnieks et al. (2011) conducted their study among 29 older adults aged 71 to 83 years (mean (SD) =78 (3)) (Sturnieks et al., 2011). The disparity of the populations might explain the difference in results (Sturnieks et al., 2011). Thus, further study is needed to explore the relationship of both measures (swaymeter measured by PPA and force plate measures by computerised posturography) among older adults with cognitive impairment.

The limits of stability test was only carried out on 6 (46%) participants as those participants who had a history of falling were unable to complete the test. This implies that the limits of stability test was challenging for these participants. I chose to correlate the limits of stability test with the hand reaction time test for the PPA because it may relate to the perception-action task that is an important mechanism in postural control. In both tasks, participants focus on goal-directed, eye-limb movement. In the former test, the participant has to lean the body towards the respective visual target presented on the test screen whereas, in the latter test, the participant responds by clicking a mouse in response to seeing a presented light stimulus. In cognitive neuroscience, the process of rapid, online visual selection is referred to as “attention” (or “selective attention”), and the eye movements used to scan the environment are known as saccades or rapid eye movements. This is a behaviour that requires attentional demands (Galgon, Shewokis, & Tucker, 2010). Attentional demands are one of the known causes of instability in older adults with mild to moderate cognitive impairment as describe in Chapter 4.

I made an attempt to correlate the tests of the PPA and those of computerised posturography that have vision components; they did not correlate. The constructs of these two tests are different and this might explain this result. The PPA assesses visual acuity by participants identifying various orientations in pictures containing edges that
reduce in visual contrast, whereas visual dependency is tested in computerised posturography by participants maintaining postural stability in quiet standing with EO and EC, data from which are then used to calculate the Romberg ratio (Isableu et al., 2003; Lacour et al., 1997).

Proprioception is important as for the awareness of body position via the movement and forces acting on the body (Hurler, Rees, & Newham, 1998). Proprioception requires the integration of sensory information from many components including peripheral proprioceptors (i.e., muscle spindles, Golgi tendon organ), vision and vestibular input (Hurler et al., 1998). I hypothesised that the proprioception test of the PPA might associate with the sit to stand test. The sit to stand test has been found to correlate with quadriceps muscle strength in young but not in older adults (Hurley, Rees, & Newham, 1998), the latter findings explained by impaired proprioception due to reducing muscle spindle sensitivity with ageing (Miwa, Miwa, & Kanda, 1995; Sturnieks, St George, & Lord, 2008). Thus, one might argue the validity of the proprioception test of PPA to be beneficial in accurately detecting falls risk in older adults. Thus, more study is needed to explore the validity of the proprioception test of the PPA.

The TUG test did not show any agreement with the walk across test measured by computerised posturography. The nature of the test might explain this discrepancy. While in the TUG test, a participant may need to accelerate and decelerate twice, while transferring positions, and before and after turning, the walk across only requires one acceleration - deceleration execution. The earlier construction of the TUG test by Podsiadlo and Richardson (1991) showed good correlation between time score in the TUG test and gait speed. However, this study was conducted among institutional older adults (Podsiadlo & Richardson, 1991) who may have reduced overall functional capacity. In a study by Wall et al. (2000), these researchers suggested isolating each component of the TUG test to further investigate which functional component is impaired (Wall et al., 2000). They measured the time taken at 6 points: sit to stand; gait initiation; walk; turn around; walk again; slow down, stop and sit down (Wall et al., 2000). It might be that the components of turning and standing up are compromised among older adults with cognitive impairment, thus increasing the time taken to
complete these tasks, explaining my findings of a correlation between the TUG test and the step quick turn test.

5.8.2 Sensitivity, specificity and ROC curve: the ability of the Physiological Profile Approach and the Timed Up and Go test to distinguish between fallers and non-fallers

The Physiological Profile Approach

In this study the Physiological Profile Approach test produced a 75% accuracy, a low sensitivity 33% and a high specificity 89% for predicting falls in older adults with self-reported memory loss. The ROC curve cut off of 2 achieved best specificity to discriminate between fallers and non-fallers. This cut off point of 2 was similar that reported by Lord et al. (2003). Lord et al. (2003) showed that in a general older adult population, the cut off point is > 2 or < 2 to predict an older adult as “at risk of fall” or “not at risk”, with 75% accuracy in predicting fall (Lord & Dayhew, 2001; Lord et al., 2003; Lord et al., 1994; Lord et al., 1994a). I tested the PPA for its accuracy to predict falling among older adults with self-reported memory loss by calculating ROC curves. Of the 12 participants in my study, three had a history of falling in the past year. Participants’ PPA scores were compared with their history of known falls. Although I found a cut off point of 2, due to the small sample size the results of my findings must be viewed with caution and I was unable to confirm that a cut off point score of 2 is sensitive to discriminate between fallers and non-fallers among older adults with self-memory loss. To my knowledge, no study has evaluated the predictive value to rate the older adult with cognitive impairment in terms of their risk of falling, using the PPA. Thus comparisons could not be made and this is an area of future study.

Timed Up and Go test

In the current study, the TUG produced 69% accuracy, high sensitivity 75% and high specificity 67% to predict falls in older adults with self-reported memory loss. The ROC curve cut off of 13 seconds achieved best sensitivity and specificity to discriminate between fallers and non-fallers in older adults with self-reported memory loss. Participants’ TUG times were compared to their history of known falls (i.e., if they had experienced more than one fall in the past year). The TUG test was then tested
for its accuracy among older adults with self-reported memory loss by calculating ROC curves. Screening the results of 13 participants found that four participants had a known history of falls (n = 4). The TUG test is designed to test functional balance and mobility. Based on a study by Shumway-Cook et al. (2000) a cut off point of 13.5 seconds predicts “at risk of fall” (> 13.5s) or “not at risk” (< 13.5s) in community dwelling older adults (Shumway-Cook et al., 2000). Thus, the results of my study were able to conclude, with caution given the low sample size and very low falls rate, that the cut off point of 13 seconds measured by the TUG test is sensitive and specific to discriminate between fallers and non-fallers among older adults with self-reported memory loss.

There is a lack of studies on the prediction of falls in older adults with cognitive impairment using the TUG test. Many previous studies have evaluated this test among community-dwelling older adults (Arnold & Faulkner, 2007; Beauchet et al., 2008; Chiu, Au-Yeung, & Lo, 2003; Okumiya et al., 1998; Rose, Jones, & Lucchese, 2002; Shumway-Cook et al., 2000; Thrane, Joakimsen, & Thornquist, 2007), inpatients with mixture of conditions (Large, Gan, Basic, & Jennings, 2006; Lindsay, James, & Kippen, 2004; Thomas & Lane, 2005) and very frail older adults in a retirement village (Gunter, White, Hayes, & Snow, 2000), without specifically targeting community-dwelling, older adults with cognitive impairment. The cut off time from these studies ranges from 10 to 32 seconds, the range most likely due to heterogeneity of the populations studied. Studies conducted with those living in the community reported on participants who were healthy and high functioning (Arnold & Faulkner, 2007; Beauchet et al., 2008; Chiu et al., 2003; Okumiya et al., 1998; Rose et al., 2002; Shumway-Cook et al., 2000; Thrane et al., 2007), unlike in my study where participants, although independently mobile and community-dwelling, had mild to moderate cognitive impairment (MMSE of mean (SD) =19 (9), range 14-28). There is insufficient data for comparison and my data are not directly transferable due to variations in populations sampled. Thus investigating the predictive cut off time of the TUG test with a large sample size to predict falls among older adults with cognitive impairment who are living in the community, is another area of future research. There
is also a need to investigate TUG cognitive to measure postural stability in dual task performance and I acknowledge this is a limitation of the current study.

5.8.3 Comparison of postural stability performance between fallers and non-fallers who are older adults with self-reported memory loss

The performance of postural stability between fallers and non-fallers was not significantly different except for turning to the right during step quick turn test ($z = -2.046$, $p = 0.04$). The reason for this might be related to the small sample size, precluding the ability to demonstrate significant differences. Studies that employ large samples are warranted.

5.9 Practicality of the tests between laboratory computerised posturography and clinical measures of postural stability

In my study, nine participants were unable to fully complete the computerised posturography tests, yet only one participant refused to complete the PPA and all thirteen participants could safely complete the TUG test. These findings indicate that the TUG and PPA appear to have more utility/ease of use for older adults with self-reported memory loss. Having incomplete data due to an inability to perform a test is a special concern in when researching the elderly (Fergusson et al., 2002; Hardy et al., 2009). A percentage of missing data of over 5% can introduce biases in the estimation of the effect and, thus, evaluating the practicality of test performance is warranted when undertaking research with older adults with cognitive impairment (Hardy et al., 2009). The high proportion of participants who were unable to complete the mCTSIB and the limits of stability tests support use of the TUG test and the PPA as more practical outcome measures for use with this population. Moreover, the completeness of the TUG test and the PPA indicate that older adults were able to perform these tests without fear of falling. This thereby increases the utility of these tests of postural stability for older adults with self-reported memory loss, in the community.

Two reasons may explain why incomplete data were collected for the mCTSIB and limits of stability tests: 1) Higher cognitive impairment: Participants with MMSE scores below 22 ($n = 6$) were unable to fully complete all the tests; 2) Participants with
confirmed diagnoses of dementia (n = 2) were not able to fully complete all the tests. This result is in line with my systematic review that found older adults with mild to moderate cognitive impairment have reduced static postural stability compared with their healthy peers, when measured with computerised posturography (see Chapter 4).

Participants had difficulty in completing two tests of the computerised posturography: (1) eyes closed standing on the foam and (2) the limits of stability test in all eight directions. This is not surprising as these two tests specifically challenge postural stability, as shown in previous studies of performing such tests with EC (Dickin & Rose, 2004; Gago et al., 2014; Leandri et al., 2009; Mignardot et al., 2014) (mCTSIB) (Suttanon et al., 2012a) and on an unstable surface (Dickin & Rose, 2004; Suttanon et al., 2012a). As described earlier, although the “eyes closed standing on the foam” test of the mCTSIB is similar to the sway test of the PPA (where participants were able to complete the sway test), the former test uses a lower density foam than the PPA, thereby providing more challenge to postural stability (Patel et al., 2008).

During the limits of stability test, participants were unable to maintain stability in all eight directions. It was observed that they first tried to use their ankle strategy to maintain stability; however, after a while, their hip strategy became more apparent and when the sway was beyond their limit of stability, they used a stepping strategy to prevent a fall. These three strategies are well described movement strategies that enable an individual to return the body equilibrium into a stable standing position (Horak, 1987; McIlroy & Maki, 1996). A previous study, however, found that older adults favour stepping as a fall prevention strategy (Brown, Shumway-Cook, & Woollacott, 1999), which is in line with what was observed in the current study.

5.10 Findings synthesising and inferences
Given the findings of this study, the cut off point of 13 seconds for the TUG test was used for the final proof of concept study (Chapter 7). I was, however, not confident to suggest the cut off point of > 2 or < 2 to predict an older adult with cognitive issue as “at risk of fall” or “not at risk”, respectively, when using the PPA, especially as this result was not significant. But, I therefore decided to use the standard cut off point of
PPA as recommended by Lord et al. (2003) (Lord et al., 2003), that of > 2 or < 2 in my proof of concept study; this similarity was due to chance. Although, one might argue that PPA is not sensitive enough to be used to predict the risk fall, PPA is a set tests that has value in screening risk of falls. Moreover, PPA is transportable and easy to use in the community.

5.11 Limitations

The findings of this study need to be interpreted within the context of its limitations. The first limitation was its small sample size; this was because recruitment of participants using my study’s “Alzheimer’s disease” and “mild-to-moderate impairment” eligibility criteria (detailed in 5.7.1 above) proved challenging. I tried to recruit participants from the community, retirement villages and long term care facilities in Dunedin and Mosgiel, a small city and a small town (combined population approximately 125 thousand) in south of the South Island of New Zealand. However, the response rate was low. Eleven of the 13 participants were from a dementia day care centre in Dunedin and two participants heard about the research from the Alzheimer’s Society Otago newsletter. Although this low recruitment may partly be due to the low overall population in this region, it may also be due to participants’ denial of potential cognitive problems and potential diagnosis. Fronting up to the fact that one has cognitive problems, seeking helping for this, even in the case of a confirmed diagnosis, may be difficult. This difficulty is partly due to the stigma that this diagnosis holds and partly due to the subsequent consequences of it in terms of loss of independence and autonomy (Garand et al., 2009).

This leads to the second limitation, that of heterogeneity of the population. My sample was heterogeneous in that it likely included people with Alzheimer’s disease, other forms of dementia, frontotemporal, and cognitive impairment. I minimised the exclusion criteria to maximise data completion; a strategy recommended when there are limited resources (Hardy et al., 2009). This might imply the population in Dunedin has a heterogeneous nature of cognitive impairment, but without a formal memory clinic or structured pathway of care for older adults with memory loss, in Dunedin at the time of my study, it is hard to confirm. Most participants were members of a dementia care
programme; however, we could not confirm the diagnosis of all participants. The participants’ cognitive impairment status was thus solely based on their MMSE score which, if between 10-28, indicates mild to moderate cognitive impairment (Folstein et al., 1975; Suttanon et al., 2013a; Wesson et al., 2013).

The third limitation was that, although I repeated instructions when necessary and used cues to direct and assist participants to finish the task, as well as having support people present during testing, some participants with moderate cognitive impairment could not complete all tasks and this resulted in incomplete data. The results may not be able to be generalised to the broader population (Hardy et al., 2009).

5.12 Summary
This study suggests that older adults with cognitive impairment have a higher risk of experiencing falls than healthy peers. The results also suggest that the Physiological Profile Approach and the Timed Up and Go test might be practical tools for predicting fall risk and measuring postural stability in a community setting. I therefore decided to use them both as outcomes measures in my proof of concept study. This said, given the small sample size in this study, the results must be considered cautiously.

The next chapter describes a qualitative study undertaken to understand, from the perspective of older adults with self-reported memory loss and their support people, how an exercise-based intervention to improve postural stability and reduce the risk of falling could be suitable delivered to optimise engagement.
CHAPTER 6: Study 3

Exploration of the best way to deliver an exercise programme to improve postural stability in older adult with self-reported memory loss: A qualitative study

6.1 Introduction

The previous chapter presented and discussed the psychometric properties of the Timed Up and Go (TUG) test and Physiological Profile Approach (PPA). This chapter reports on my qualitative study in which I interviewed older adults with self-reported memory loss and their support people.

6.2 Aims of the qualitative study

This qualitative study primarily aimed to explore how older adults with mild to moderate cognitive impairment perceived the ideal composition and delivery of an exercise programme to improve postural stability for themselves, while optimising adherence.

The secondary aims were to explore how older adults with mild to moderate cognitive impairment perceived:

- their postural stability at present.
- the benefits of exercise.
- their motivations for, and the barriers to, doing exercise.
- Alzheimer’s disease or cognitive impairment.
6.3 Methods

This qualitative chapter is an aspect of the development of the complex intervention, and provides relevant theory for the intervention’s design.

6.3.1 Study design

Semi-structured face-to-face interviews were undertaken with older adults with cognitive impairment and their support person / significant others.

The study was approved by the University of Otago Human Ethics Committee (Health): H14/035.

6.3.2 Participants

Participants with mild to moderate cognitive impairment were recruited following their participation in the psychometric properties study (Chapter 5). Participants were purposefully selected to ensure they could understand and communicate sufficiently to interact in a meaningful way (Hubbard et al., 2003; Mozley et al., 1999; Zhua et al., 2015). The details about participant recruitment, and the inclusion and exclusion criteria were discussed previously in Chapter 5. Participants were informed about the possibility of taking part in qualitative interviews when they were recruited for the psychometric properties study. Participants could provide signed consent to participate in both or either study. I purposely asked nine of the 11 participants to participate. The remaining two were not asked because of the development of ill-health.

Participants were encouraged each to choose a support person and, where possible, were then each interviewed together with that person. Nine participants and six agreed support person consented to be in the qualitative study. Seven interviews were conducted with the participant and their support person and two interviews with just the participant. All interviews were conducted in a mutually agreed venue.

To differentiate the older adults with mild to moderate cognitive impairment participants from the psychometric study (Chapter 5) and this chapter, the term ‘interviewees’ will be used throughout the remainder of this chapter, and ‘caregiver’ to
indicate a support person / significant others who is central to the care of the interviewee.

6.3.3 The interview procedure and data collection

The interviews were initially conducted by myself and one of my supervisors until it was felt a) that I was sufficiently confident to continue independently (being naive to qualitative research and with English as my second language), and b) that the questions elicited the responses in sufficient breadth and depth to answer the aims of the study. I then undertook the remaining interviews. This also served as an opportunity for me to become familiar with handling the Sony ICD-UX300F voice recorder.

The date, time and venue of the interview were scheduled at each interviewee’s convenience but within a week of completing the psychometric study. The interviewee and the caregiver provided signed informed consent to be part of the interview at the time of the interview.

A summary of the key questions from the interview schedule is presented in Table 6.1. The interview schedule can be viewed in Appendix E. The schedule was based on discussions with my supervisors and from my reading of the literature (Buchman, Boyle, Wilson, Tang, & Bennett, 2007; Suttanon et al., 2012) and was used to format each interview. The sequence of questioning changed according to how the interview developed and with respect to where interviewees and caregivers wished to focus. Each interview was recorded with a Sony ICD-UX300F voice recorder. Each interview session started with a re-briefing about the aims of the study and what they were agreeing to, with respect to their data.
Table 6.1 Primary interview questions

<table>
<thead>
<tr>
<th>Questions</th>
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<tbody>
<tr>
<td>Describe what your balance or stability is like at present.</td>
</tr>
<tr>
<td>Describe any issue you have with your balance or stability.</td>
</tr>
<tr>
<td>Describe how you think exercise might benefit you.</td>
</tr>
<tr>
<td>How do you think an exercise programme could be delivered to maximise</td>
</tr>
<tr>
<td>participation and adherence?</td>
</tr>
<tr>
<td>What would help you to exercise regularly?</td>
</tr>
<tr>
<td>What would stop you from exercising regularly?</td>
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</tbody>
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6.4 Data analysis

To address the primary aim of this study, data were analysed using a General Inductive Approach (Thomas, 2006). This type of qualitative analysis explores the raw data for significant themes, but without the limitations imposed by structured methodologies (Thomas, 2006). Whilst this is a more useful approach in evaluative research, I used it in this study for its ability to establish links and association between research objectives and the summary findings produced from the raw data and thus purposefully inform the development of the intervention (Thomas, 2006). There are five steps in the process of inductive coding: (1) preparation of the raw data; (2) close reading of the text; (3) develop categories; (4) overlapping categories and un-categorised text; and (5) revision and modification of the categories.

To address the secondary aims, I interrogated the raw data in more depth, using a phenomenological approach to explore participants’ perceptions their postural stability, memory loss and exercise.

All nine interviews were transcribed word for word by myself. Later, each transcript was crosschecked to the recorded interview, word by word, by an independent person (PM) not involved with the research, to reduce errors in the transcribing.

Once the transcribed data files were cleaned, I read the text data closely. On the first couple of readings, I read while listening carefully to the audio recordings and noted
down any interesting ideas, possible codes and intonation in the text. By this means, potential codes were generated through line by line open coding; each code having its unique meaning. Both the similarities and the differences in the perspective between individual interviewee and caregiver responses were noted. After multiple readings of each individual transcript, coding and re-coding were conducted to ensure the codes answered the research questions. The codes were then refined further and collapsed into categories reflecting codes with similar meaning. Within each category, exemplar quotations were selected to convey the core primary theme of the category for inclusion in the written results.

For a more in depth analysis and to construct linkages between coded data, a few further steps were taken. Firstly, I identified important key words and/or sentences relating to the phenomenon under study (Goulding, 2005). For each of these important statements, I created a theme and articulated the meaning the theme held in the context of this study (Goulding, 2005). The process was repeated with all raw data and recurrent themes were clustered (Goulding, 2005). Later, each of the themes was integrated and linked together to explain the behaviour or the process presented by the themes (Goulding, 2005).

6.4.1 Rigour, trustworthiness and credibility

In qualitative research, there are four types of trustworthiness: credibility, transferability, dependability, and confirmability (Guba & Lincoln, 1994). To establish credibility, the data were analysed independently by my supervisors (MP and LH) to verify the categorisation of data as a consistency check. Each supervisor was given two transcripts to read, to independently code to ensure the research had accurately encapsulated the participants’ viewpoints into the data for dependability (Graneheim & Lundman, 2004). Further refinement occurred on another few occasions during discussions with the whole research team as to the how the key themes related to each other. The refinement occurred until a consensus was reached. A summary of the preliminary results of the analysis was presented in plain language to participants for feedback. This form of stakeholder check resulted in no modification of the refined categories verification.
6.5 Findings

6.5.1 Demographic data

Table 6.2 reports the demographic characteristics of the nine interviewees (six males and three females) and their respective participating caregivers. Three interviewees with their caregivers were interviewed in a private room at the School of Physiotherapy; five were interviewed at the interviewees’ respective homes; and one was interviewed at a mutually agreed place (a café). The duration of the interviews ranged from 30 - 60 minutes.

The age of the interviewees ranged from 71-91 (mean 80) years. Four interviewees lived in the community, and five lived in a retirement village. A retirement village in this context is a residential area or housing complex designed for older adults who are independent, i.e. able to care for themselves. The home care agency might assist in terms of socialisation opportunities and activities for some of the communities. Six interviewees had mild cognitive impairment, and three had a moderate cognitive impairment based on the Mini Mental State Examination (MMSE). Five interviewees had a range of one to three additional medical conditions. These other conditions included diabetes, hypertension, arthritis, knee and hip replacement and respiratory problems. All participants were able to ambulate independently; however, two participants used a walking stick for outdoor activities.

Six caregivers, ages ranging between 65-76 (mean 70) years, also participated. Only two caregivers had one or more medical conditions, including hypertension, diabetes, heart disease, back pain, arthritis and respiratory problems. All caregivers were female and a spouse to the respective interviewee.
Table 6.2 Characteristics of interviewees

<table>
<thead>
<tr>
<th>Interviewee with cognitive impairment</th>
<th>Caregivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudo.</td>
<td>Gender</td>
</tr>
<tr>
<td>Alden</td>
<td>Male</td>
</tr>
<tr>
<td>Bradley</td>
<td>Male</td>
</tr>
<tr>
<td>Raymond</td>
<td>Male</td>
</tr>
<tr>
<td>Zain</td>
<td>Male</td>
</tr>
<tr>
<td>Ashly</td>
<td>Female</td>
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<tr>
<td>Daisy</td>
<td>Female</td>
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<tr>
<td>Dane</td>
<td>Male</td>
</tr>
<tr>
<td>Hazel</td>
<td>Female</td>
</tr>
<tr>
<td>Earl</td>
<td>Male</td>
</tr>
</tbody>
</table>

Notes: MC, medical condition; MMSE, Mini Mental State Examination; R, relationship, Pseudo; pseudonym.

6.5.2 Primary themes and subthemes: Overview

The main aim of the qualitative study was to explore opinions of how best to deliver an exercise programme to improve postural stability for older adults with mild to moderate cognitive impairment that would optimise adherence. The findings related to this aim are detailed below under the following themes: 1) Awareness; 2) Denial; and 3) Coping strategies. The findings also seem overlapped in some of the themes. The key points of the best way to deliver an exercise programme were answered by the themes ‘denial’ and ‘coping strategies’, whereas the target component of postural stability answered by the theme ‘awareness’. Within the theme ‘denial’, led to the result that there was a need for an individual-based exercise programme. Whereas in the ‘coping strategies’ theme, the findings could be explained by four characteristics of activities that should be incorporated into the exercise programme: enjoyable and pleasurable activities; support systems; short duration; and cognitive stimulation. Within support systems, it was thought that group-based exercise might be a potentially favourable method to deliver the exercises. The areas that should possibly be targeted areas for postural stability were illustrated largely by the theme ‘awareness’. These areas included complex tasks, such as climbing up ladders, turning, traversing different terrains and elevations of footpaths, and unforeseen perturbation. Changes to vision were also highlighted as an important reason for postural instability.
In addition to addressing the primary aim, I also wished to explore how the interviewees perceived their postural stability, the benefits of exercises, the motivations and the barriers, if any, to exercising, and how they perceived Alzheimer’s disease and cognitive impairment. A cyclic process that participants reported they experienced, is illustrated by the conceptual framework in *Figure 6.1*. This conceptual framework demonstrates the linkage between key cyclic processes. Although a secondary aim, these findings are both interesting and informative and provide the underpinning context for the intervention development decisions. Thus, I have spent some time in detailing them below.
The cyclic processes

Figure 6.1 shows how cognitive and physical impairments changed the interviewees’ psychological perception of themselves, and how this altered perception impacts their daily activities and decision making for everyday activities. The cycle process was not necessarily linear in progression, but circuitous, moving up and down or skipping from
one phase to another throughout. The cycle process involved four complex stages: awareness, denial, acceptance and coping strategies.

In the early phase of the diagnosis (white boxes, blue line), there are three prominent complex cycles: 1. ‘Awareness’ – ‘denial’ – ‘acceptance’ – ‘coping strategy’; 2 ‘Awareness’ – ‘denial’ – ‘coping strategies’ – ‘acceptance’ – ‘coping strategies’; 3. ‘Awareness’ – ‘acceptance’ – ‘coping strategy’. Later, as the disease progresses (red line), in each cycle, the process goes back to the first box (linkage between deterioration of cognitive versus physical performance) as per the earlier phase of the cycles. As the level of awareness changes, the new changes in physical and cognitive ability are noticed and the new cycle is developed that then influences the build-up of new coping strategies. This cycling process continued again and again. As the cycle continues, the stage on the cycle will determine every decision of how the interviewee wishes their individualised exercise intervention to be. This is explained further below.

**Brief description of the linkage in each phase on the cycle processes.**

The ‘awareness’ illustrates the initial phase of perception of the interviewees towards the conditions of the cognitive impairment that they were currently experiencing. It was a complex phase as it leads to the second key theme, ‘denial’. Before the perception of ‘denial’ become intense internally, the awareness of ‘recognition of deterioration’ of physical and cognitive function comes into play. However, because the interviewees are in the earlier phase of their condition, this awareness enables them to ‘recognise[d] the benefits of exercise’.

As the awareness of deterioration in cognitive and physical ability become more apparent, the emotional consequences result in ‘denial’. Denial can strongly influence the sub-theme of ‘social withdrawal’ or it can be followed by ‘acceptance’ of the deterioration. It seems ‘denial’ can overlap with ‘acceptance’, in that the interviewee can appear to deny their new limitations due to a reduction in their cognitive function, but then the ‘self-regulatory’ state, as a way to cope with their new limitations, kicks in; thus they are simultaneously denying but adjusting. Within the sub-theme of ‘social withdrawal’ there was a parallel process of reaction within the interviewee. There were
‘stigmatised’ and ‘labelling’ states that were found to be associated with the reasons of enacting ‘socially withdrawal’.

As a step to cope with every new presenting limitation, and due to this ‘self-regulatory’ ability, the interviewees attempt to formulate ‘coping strategies’, which was the third key process. The interviewees continue their lives by doing ‘enjoyable and pleasant activities’ and involve themselves with the help of a ‘support system’ that they can easily access.

As this complex interaction between themes grows, the interviewees return to the earlier cycle process point of ‘awareness’, and at this stage, because of the reality of their previous awareness becoming limited might become more apparent among the interviewees, the caregivers talked of the ‘linkage between the deterioration of the cognitive and the deterioration of the physical performance’.

**Awareness**

Changes in cognitive function was the main concern of all the interviewees. The changes were described as a gradual deterioration over time, with progression of the dementia, which made the completion of tasks difficult. The interviewees also recognised the deterioration of physical ability, as tasks required more effort and resulted in fatigue. How much interviewees perceived that they had deteriorated cognitively and physically was dependent on the level of the ‘awareness’ they had currently. As awareness also became limited, progression of the deterioration became more evident and was recognised by the caregivers.

**Recognition of the deterioration of cognitive function**

As the dementia progressed, changes in cognition were described as a loss of reasoning, judging, organising and planning. It made completing everyday tasks difficult, a caregiver raised and mentioned that Dane has difficulty in organising the furniture to improve is lost “I think another significant part of the discussion is about the simple everyday [task]. How do I organise my furniture to make life easy and comfortable?
And [Dane], could not think that through. He could not make that himself.” (Elisa-caregiver)

One of the caregivers shared some experiences relating to “concentration” and “following instruction” (Sabrina-caregiver) demonstrating how these prevented daily task completion: “I [have] observed that it is very hard for you to eliminate distraction and stay on task and focus on what you [are] doing.” (Sabrina-caregiver)

Changes in mental capacity for her husband raised concerns for the caregiver about the ability to safely complete activities of daily life. For example, Hayley shared the experience where her husband got lost on the way back home after taking the dog for a walk one day:

One day, not that long ago when he did not do his normal walk. He went a different way, [a] different place and [it] was took him a [a bit] longer. I thought he was lost. Nobody else knew that. So you know, as you get worse, what we know is [it is] going to happen. So it is better doing exercise with people rather than alone. (Hayley-caregiver)

In additional to that, speech was also affected, making communication frustrating. Although the interviewee did not believe that speech was affected, this was recognised and mentioned by the caregiver:

He has trouble getting the word in the right order. [It is] not bad, but sometimes you [Bradley] get frustrated because you want to say something, but it does not come out the way that you want [it] to come out. Moreover, it is not every time it is out of the blue. (Edith-caregiver)
Recognition of the deterioration of the physical performance

There was recognition that because cognition was declining, basic motor skills were deteriorating over time, too. The interviewees believed that their postural stability was “all right” (Daisy) and “reasonably good” (Ashly) with activities such as walking and running “with some caution” (Alden), although the terrain did make a difference: “It is not problems on the flat floor indoors.” (Dane).

The interviewees also believed that an assistive device, such as a “walking stick” helped them to walk even though they could not walk the same distances as previously and that they “need[ed] to go out, otherwise you will deteriorate.” (Hazel).

However, the ability to complete more complex tasks in the same manner as previously done, was frequently noted by the caregivers. For example, one caregiver said: “[He was] fine [during] walking and running, [but] climbing the step ladder, [he] needs to hold, as it shakes. He is a bit shaky.” (Alden).

Interviewees did recognise that their postural stability had deteriorated when the same physical response happened on recurrent occasions. For example, they reported feeling consistently unstable with quick turning, or that they regularly missed changes in elevation of the footpath. However, they did not consider these changes to be “a great problem [but] more an annoyance” (Dane). This interviewee, although aware of the postural stability deterioration, had limited awareness that it might be due to pathological changes in the brain. Many of these episodes of instability were observed by the caregivers, and they felt that the frequency of these events increased progressively over time. Sometimes, interviewees attached the cause of an instability episode to an impairment in, for example, vision, but the caregiver would dispute this attribution:

As an outside observer [there is] nothing [to] tell me why you trip. However, several times when it happened, it does not happen a lot, sometimes when it happened, you said to me ‘it is my progressive lenses I do not see the depth properly of things’. (Elisa-caregiver)
In addition, the interviewees recognised that the reaction time when responding to an unforeseen perturbation, for example, the “response on…catching of the foot [is] slower” (Dane) than it used to be and that the “coordination, it seems becoming more affected” (Raymond).

**Linkage between the deterioration of cognitive and physical performance**

As the level of awareness became more apparent and also when lack of awareness became the major limitation, caregivers recognised the link between the deterioration of cognitive and physical performance. One support person reported: “Obviously, it is a strong relationship between mental efficiency and physical efficiency or ability. It is too much association.” (Hayley-caregiver)

Elisa mentioned how the “rhythm” of the body movement affected her husband since he was diagnosed as having dementia and “it is spread slowly into the other areas of his life” (Elisa-caregiver).

**Denial**

As the discussion on exercises to keep the brain active developed in the interviews, one interviewee displayed distressed behaviour that demonstrated a lack of acceptance or denial: “I feel agitated now, or [I am] not really” (Raymond). On another occasion, the same interviewee demonstrated discontent with his caregiver as she explained the difficulties as his memory issues got worse over time. These behaviours around a lack of acceptance and discontent could result in being ‘stigmatised’ of older adults with diagnosed of Alzheimer’s disease might experience. His awareness of the possible deterioration of quality of life was exemplified on the occasion where his caregiver was sharing about the importance of being involved in physical activity once he had “stopped working”.

**Social withdrawal**

Alden expressed that he did “not want to be in the group. I just do not want” while Raymond felt “embarrass[ed]” an embarrassment that might be link to ‘labelling’ (theme) when other people discovered, or attributed some of his behaviours to, his
Alzheimer’s disease. It was also hard for the caregiver to accept: “It is unacceptable change on you, like memory is [progressively deteriorating].” (Elisa)

Acceptance

Other interviewees rationalised the situation their diagnosis put them in by thinking about what they had achieved in life, being grateful for the good things and contextualising the condition as a normal part of the ageing process. This demonstrates that these interviewees tended to normalise the situation despite having difficulties due to the memory issue. While others, although they felt as though they had accepted the disease, were in a quandary as to whether they should push themselves to be more physically active and maintain what they currently had or to gracefully accept solutions to each limitation, such as using a mobility scooter once the ability to walk independently was gone. Even so, the internal conflict to just accept was evident. For example, one interviewee described the numerous successful things in her life such as “rais[ing] seven children” but suggested that now “it is the time for [her] to rest”, yet:

I have realised that I have to help myself, I have to push myself a bit more and you know I have been to the church this morning. One of my friends picks me up and brings me along which is very nice, especially when it is raining and you know. I do not know, maybe I should push myself a bit more to be more enthusiastic [but] then I think ‘Why I do this silly thing?’ I am 91 years old and accept the fact that I am 91 but, I honestly do not know. (Ashly)

Self-regulatory

Regardless of whether interviewees accepted or denied their deteriorating cognitive and physical performance, interviewees built up self-regulation by participating in activities on their own initiative. For example, Ashley was, and wanted to remain, independent. She liked her “body to [function] properly” and “that is the main push”. “I think once my routine is being established, I’ll keep it going.” (Ashly)

Interviewees also acknowledged the changes in life, and they attempted to adjust in their way. It was important to the interviewee that they attempt to stick to familiar
“routines”, to be able to function and demonstrate strategies of self-compensating. Support from caregivers was also invaluable. Caregivers provided interviewees with strategies to overcome short term memory loss so that they could remember the tasks to be completed during that day. Reminders included a “phone call” (Elisa-caregiver) during the day or a “note” or “lists” (Hayley-caregiver) placed strategically around the home.

We have a strategy for Dane coming down here today to meet up with you. The night before I am talking to him on the telephone. I get him to write on a piece of paper to put on his breakfast tray, and he needs to catch the bus, and he has to be here by this time. (Elisa-caregiver)

Coping strategies
All interviewees and caregivers expressed the need for strategies to cope with their daily life activities. Every limitation was seen as “challenges” that triggered them to formulate a new solution that would maintain the quality of life that they wanted. The strategies kept changing as they were highly dependent on the ability of the interviewee to follow. Support came mainly from the caregivers and other organisations, for example, Red Cross and walking groups.

Enjoyed and pleasure activities
The interviewees shared the activities undertaken in the natural environment that were meaningful to them. They “walk[ed] to the supermarket rather than take a car or bus and carrying the groceries”. Even though they realised the groceries was “quite heavy” they described it as “a good exercise”. The interviewees enjoyed walking and doing activities such as “bending down to pick up the [rubbish] along the road” (Alden). Dane and Hazel also enjoyed walking in nature settings and relished the “beautiful environment” while “listening to the birds cheeping”.

Ashly felt pleasure when she walked into her garden even though she did not feel confident about her ability to get there due to the distance:
I feel pleasure. I am not that very brave, but one day I thought ‘I did not go to the garden for so long’. I was very brave, I am not very confident, but I feel I have to try. (Ashly)

**Support systems**

Financial support from organisations as well as individual support at exercise sessions was appreciated and influenced the decision to participate or not. The interviewees valued being able to get support from health care providers who made exercises easy to “copy and remember” (Daisy). “No, it is not the time, but expenses to and from. I get from the Red Cross. They only allow me to do one day a week because they are so busy.” (Daisy)

The existing group activities, for instance the ‘walking group’, encouraged interviewees to participate in a more relaxing activity without any peer pressure. This was because they believed that everyone could walk whatever the level of cognitive function and age. The caregivers recommended structured exercises for older adults with cognitive impairment. One caregiver suggested one group activity that is frequently played in Dunedin: the petanque game. In petanque, the player has to throw a ball to get as close as possible to a small target ball. The petanque game provided slow, gentle body movements which was favoured among older adults with various ages and abilities:

People play that particular game right through their 90s, from the age of 12. There are a good portion of people over the age of 70 who have different degrees of dementia playing that game. But because of the level of the activity, they still can do it. (Hayley-caregiver)

Both the interviewees and the caregivers recognised the benefits of exercise. Most of the interviewees demonstrated that, despite deterioration in physical performance and cognitive capacity, they believed that exercise could keep them “fit”, “increase strength”, stimulate and facilitate the development of “social” connectedness with a spouse, friends and acquaintances. They mentioned how they enjoyed and were grateful when they participated in exercise:
Oh well, if I did not have a little dog, I will not bother going walking alone in the park unless my wife says, let’s have a walk. [But] I have company, my dog is my company and so we enjoy that. [Walking] by myself, I doubt about it. But I [am] still interested in doing [activities] that keep my body fit because I like to be fit. (Raymond)

The interviewees and the caregivers also described what they thought were the positive aspects of being in an exercise group, such as the social elements and getting to know about others.

You [walk] to the changing room [and] you can acquaint yourself with some people. You do not know anything about them, they do not know anything about you but you….you start talking. There is a Chinese [person] that I talk to regularly. (Dane)

However, there were interviewees that had no opinions regarding the benefits of the exercise. These interviewees only agreed with the caregivers and said “I do not know” (Zain).

**Short duration**

The caregiver recognised that the interviewee whom she cared for required additional effort, described as “enormous amount of energy” (Kelsie), to complete usual tasks. The other caregivers also recognised this and described feeling “fatigue[d]” (Hayley and Edith-caregivers) and “hopeless” (Hayley-caregivers), especially in the afternoon. Earl also mentioned that his “sleep pattern had changed” and meant that he needed to go to bed early to cope with the everyday life.

**Cognitive stimulation**

The interviewees talked about brain stimulation as a reason why certain activities were meaningful. They valued the brain stimulation that occurred with activities such as planning, justifying, calculating, communication, social interaction, and concentration
to maintain cognitive function. One interviewee mentioned how his job stimulates his brain:

> We run a business on Sunday. I organise the orders, and I enjoy selling over the telephone of course. I am pretty good at communicating with the customers. These activities keep me active. This is what I call brain exercise. If I stop doing that, which is inevitable and may be certainty, my fear is ‘Am I just going to be more [cognitively impaired]?” I like to be active because the longer I keep my mind active, I am happy. (Raymond)

Caregivers suggested that concentrating on “sound”, “smell” and “taste” could also stimulate the brain.

### 6.6 Discussion

This study aimed to explore how older adults with mild to moderate cognitive impairment perceived the ideal composition and delivery of an exercise programme to improve postural stability for themselves, while optimising adherence. The following were suggested by interviewees: 1) an individual- versus a group-based intervention; 2) include enjoyable and pleasurable activities; 3) the need for and benefits of support systems to be in place; 4) any exercise intervention should be of short duration; 5) have activities that include cognitive stimulation; and 6) include complex activities, such as climbing upstairs. These suggestions are discussed below.

The theme ‘denial’ highlighted the first characteristics of the intervention. Some participants said they preferred to exercise on their own as they felt that group exercise with others without cognitive impairment might trigger ‘stigmatisation’ when these other people recognised their cognitive limitations, thus ‘labelling’ them. The Chong et al. (2014) study also highlighted that preferring to exercise alone may also be related with the growing ‘awareness’ of physical disability (Chong et al., 2014). Conversely, some of my participants said they preferred to exercise in a group because group-based activities were seen to be more enjoyable and pleasurable, and this can be thought of as
one of their ‘coping strategies’. Therefore, the finding around this aspect: should it be better to deliver the intervention as individual- or group-based, was conflicted. Previous studies have qualitatively explored the acceptability of one or other form of exercise but have not compared them (Chong et al., 2014; King, Haskell, Young, Oka, & Stefanick, 1995; King, Taylor, Haskell, & DeBusk, 1990; Malthouse & Fox, 2014; Perri, Martin, Leermakers, Sears, & Notelovitz, 1997). Individually tailored activity was discussed in one study that employed a phenomenology analysis after a set of interventions (Suttanon et al., 2012), whereas Chong et al. (2014) explored exercise preferences using thematic analysis (Chong et al., 2014). Malthouse et al. (2014), too, explored experiences of physical activity using thematic analysis (Malthouse & Fox, 2014). These studies found both forms of exercise delivery to be acceptable (Chong et al., 2014; Malthouse & Fox, 2014; Suttanon et al., 2012). There is limited evidence evaluating participation in an individual- compared to a group-based exercise intervention, and none where participants were older adults with cognitive impairment (King et al., 1995; King et al., 1990; Perri et al., 1997). King et al. (1990) suggested that exercise at home was more preferable (King et al., 1995), whereas Perri et al. (1997) reported group-based interventions to be more successful than individual-based ones in terms of adherence and participation, even though both groups showed health improvements (Perri et al., 1997). However, these studies were conducted among obese adult women aged 40 to 60 years old (Perri et al., 1997) and healthy men and women, aged 50 to 65 years (King et al., 1995). Besides that, although meta-analysis of the best practice suggests that exercise, targeted to reduce fall risk for older adults, can be done by both types (Sherrington et al., 2011), there is no evidence, to my knowledge, about which is better for older adults with cognitive impairment. Therefore, the evaluation of individual- and group-based intervention in this population is warranted.

The theme ‘coping strategies’ highlighted two important required characteristics of an exercise intervention. The interviewees associated activities that were ‘enjoyable’ and gave ‘pleasure’ with normal and simple everyday actions, such as walking. They valued especially when the activity turned into a meaningful engagement of ‘social’ connectedness. This finding is consistent with previous evidence (Cedervall & Åberg, 2010; Chong et al., 2014; Malthouse & Fox, 2014). Cedervall and Åberg (2010) and
Malthouse et al. (2014) explored experiences of physical activity among 2 older adults aged 63 and 74 years old (MMSE = 20) and 5 older adults aged between 64 and 84 (range MMSE = 18-21) with Alzheimer’s disease and their spouses, respectively. Whereas Chong et al. (2014) explored the physical activity preferences of 50 older adults with cognitive functions ranging from normal cognition to mild cognitive impairment due to Alzheimer’s disease. The interviewees perceived enjoyable activity (Cedervall & Åberg, 2010; Chong et al., 2014) and social engagement (Cedervall & Åberg, 2010; Chong et al., 2014; Malthouse & Fox, 2014; Yu & Swartwood, 2012) were the big motivators (Cedervall & Åberg, 2010) to participate in physical activity on a daily basis. Therefore, the activities in the planned intervention should be enjoyable and aim to build social relationships.

The theme ‘coping strategies’ also highlighted another two important required characteristics of the exercise intervention, namely ‘short duration’ and ‘cognitive stimulation’. Whilst it was considered essential to incorporate exercises that challenge cognitive function, participants were aware of how fatiguing this would be, and said that the intervention needs to be of short duration. Duration of such interventions in previous studies has varied and there appears to be no evidenced-base guide. For example, studies by Ahn and Kim (2015), Mirolsky-Scala and Kraemer (2009) and Suttanon et al. (2013) involved approximately 30 minutes of exercise and they were able to show improved postural stability, measured, for example, by the Berg Balance Scale (Ahn & Kim, 2015; Mirolsky-Scala & Kraemer, 2009; Suttanon et al., 2013a). These studies however varied in sample size of populations with Alzheimer’s disease and sets of intervention: n = 23, 3x/week for 5 months (Ahn & Kim, 2015); n = 1, 3x/week, 4 weeks (Mirolsky-Scala & Kraemer, 2009); and n = 19, 5x/week for 6 months (Suttanon et al., 2013a).

Fatigue can be described in two categories, mental and physical. Although my participants highlighted the effect of cognitive fatigue with exercise participation, some studies have found that mental fatigue could be related with physical fatigue (Lorist, 2008; Lorist et al., 2000; Malaguarnera et al., 2007; Marcora, Staiano, & Manning, 2009); as the level of mental fatigue increases, so does the level of physical fatigue.
(Boksem, Meijman, & Lorist, 2006; Marcora et al., 2009). Therefore, the minimal (or ideal) time length of the intervention to be effective warrants further study.

Another important characteristic required for the intervention was for exercises that involve complex tasks, as described in the theme ‘awareness’. The complex task examples provided by the interviewees were: climbing up ladders, turning, traversing different terrains and elevations of footpaths and unforeseen perturbation. This finding is similar to that of previous studies. As highlighted in the previous chapter, these studies found that older adults with cognitive impairment have reduced postural stability in comparison with their healthy peers; for instance, they had reduced stability during execution of the perturbation test (Dickin & Rose, 2004). My qualitative study also found that participants considered deteriorating vision a problem for their postural stability, a finding similar to that of studies reported in Chapter 4 (Leandri et al., 2009; Mignardot et al., 2014; Nakamura et al., 1997). It is therefore suggested that the intervention incorporate complex activities and exercises to be done with, and without, visual feedback.

In addressing the secondary aims, data analysis identified four overarching cyclic processes: 1) awareness; 2) denial; 3) acceptance; and 4) coping strategies – reflecting the reasons for every decision made in the life by older adults with cognitive impairment. This exploration of the perceptions of my participants provides insight into how we could empower older adults with dementia. We could bolster their sense of autonomy and independence in decision-making, while emphasising activities that older adults with dementia are still able to engage in (Kihlgren, Hallgren, Norberg, & Karlsson, 1994).

The secondary analysis was deemed important to demonstrate the value of the lived experience of older adults with cognitive impairment. The first stage of the cycle was awareness, awareness of the deterioration in cognitive and physical performance. This awareness can be described as either 1) the interviewee being aware of their changed cognitive and physical performance whilst they still had cognitive reserve and this leads to denial; or 2) the interviewee lacking awareness due to the impact of declining
cognitive function and attributing the deterioration of cognitive and physical performance to ageing rather than to the pathological changes of dementia. At this stage there is internal conflict as to whether to gracefully accept or deny the diagnosis and continue the activities of daily living as per normal. At the same time, should they keep looking for the possibility of a treatment that could reverse the condition or strive to maintain cognitive function as much as possible. These qualitative findings were complex; the awareness might be explained by the biopsychosocial model which comprises neuropsychological, individual psychological and social factors (Clare, 2003; Clare, Marková, Roth, & Morris, 2011; Clare et al., 2012).

Within the biopsychosocial model, those who have high expectations of themselves might view illness as a sign of weakness and are therefore likely to deny impairment (Higgins & Thompson, 2002). Weinstein (1991) argues that denial plays an important part in adaptation and it has to be viewed as a coping strategy to an upsetting experience, such as the diagnosis of early cognitive impairment in an individual with dementia (Weinstein, 1991). With a diagnosis of the early stage dementia individuals may feel limited in their ability to contribute in a meaningful way to complete roles, tasks and pursue social interaction. It was evident that the interviewees were worried and anxious about what they might say or do, especially if it was something considered to be socially unacceptable.

The existence of denial might, however, be related with another psychological process (Weinstein, Friedland, & Wagner, 1994). This process involves a person’s fear of being stigmatised by the diagnosis of dementia, of being labelled by their peers and social community, leading to separation and withdrawal. The consequences of stigma have been defined “as a complex individual experience in which manifestations of diseases and social environments interact to affect personal identity and, ultimately, sense of self that could impact on others, for instance, the outward appearance or ability associated with the condition” (Burgener et al. (2015) p. 590). This interaction existed among the interviewees in this study as they felt uncomfortable when associating with others who have similar symptoms.
Such populations feel stigmatised once they are labelled (Link & Phelan, 2001). The label has usually a negative social meaning, that is, a person with certain diagnosis differs from others within the context of social significance (Green, Davis, Karshmer, Marsh, & Straight, 2005). From close reading of the data, you might be able to deduce that they show the internal feelings and fears of the interviewees as people surrounding them start to label by greeting them in different ways. When this feeling of being labelled is repeated over time, an internalisation process occurs, resulting in lowered self-esteem, withdrawing from social support, changed family dynamics and diminished emotional well-being (Burgener et al. 2015; Link & Phelan, 2001; MacRae, 1999; Oliver, Pearson, Coe, & Gunnell, 2005). In some instances, this labelling might cause the development of psychiatric symptoms including anxiety and depression (Hayes, 2004; Spira et al., 2007).

The major consequence from this labelling among stigmatised older adults, who have been diagnosed with dementia, is separation. Separation becomes more likely when the reactions of others to differences in appearance and demeanour, lead to a pronounced sense that others are treating them differently (Crisp, Gelder, Rix, Meltzer, & Rowlands, 2000; Green et al., 2005). This can be seen by interviewees becoming more socially withdrawn from others whether or not they have a similar illness. These findings are similar to a previous study which also found that people who do not accept their diagnosis have a high level of avoidance behaviours (Spira et al., 2007). This social withdrawal may weaken social networks and result in an increasing loss of cognitive and social stimulus (Fratiglioni, Wang, Ericsson, Maytan, & Winblad, 2000).

Another consideration of denial is a lack of awareness due to a limitation with cognitive reserves (Prigatano & Johnson, 2003; Spitznagel & Tremont, 2005). This process can be explained by a neuropsychological model. The findings illustrated that the interviewees attempted to normalise the condition by suggesting the changes were a part of a normal, natural, ageing process. The neuropsychological model suggests that the limitation of self-awareness in dementia was a reflection of damage in the right parietal and frontal lobes (Ruffman, Henry, Livingstone, & Phillips, 2008; Stuss & Alexander, 2000) that causes loss of insight and awareness (Weinstein et al., 1994).
This lack of awareness is particularly seen in people with more severe cognitive impairment (Feher, Mahurin, Inbody, Crook, & Pirozzolo, 1991; Starkstein, Sabe, Chemerinski, Jason, & Leiguarda, 1996).

From the deeper analysis of my findings, it may be that the awareness of acceptance stage of the cyclic process I described, may prompt the decision to be in a group- or an individual-based exercise programme. Interviewees who accepted their condition were maybe more willing to participate in either an individual or a group exercise programme, whereas those in denial, may prefer to do the exercises on their own at home. It seems that until acceptance of the condition occurs, there was a preference to social disconnect.

Acceptance of the diagnosis of dementia and declining functions during the progression of dementia are important for more successful participation in the dynamic process of various interventions and thus for better outcomes (Clare, 2004; Koltai, Welsh-Bohmer, & Schmechel, 2001). However, as cognitive limitations can affect decision-making-incapacity, older adults with dementia often are unable to recognise and justify the relevancy of the intervention choice that they might make (Trachsel, Hermann, & Biller-Andorno, 2015). For an example, the intervention that is constructed for a group of mixed cognitive abilities will give stimulation to older adults with cognitive impairment through constructive and inclusive engagement. This, however, requires that those with no or less cognitive impairment should have an understanding of, and respect for, those with greater cognitive impairment to avoid the stereotyping and labelling. This would enable older adults with cognitive impairment to participate in a more meaningful way. In addition, modifying the environment, for example, locating the intervention in a person’s home, may also foster participation in older adults with cognitive impairment (Trachsel et al., 2015).

The last stage of the process was developing coping strategies. The most important being that of assistance from a supportive caregiver and together formulating the best way to complete daily tasks. This can be described by the framework of Continuity Theory (Atchley, 1989). Based on the Continuity Theory, older adults with health
conditions, in this instance with cognitive impairment, adapt to the changes in their health and social circumstances by preserving and establishing an external life that supports their internal ideas of life (Atchley, 1989). For an example, in terms of my findings, older adults with cognitive impairment are looking for activities that are enjoyed and give them pleasure; at the same time they are looking for meaningful activities that could stimulate and facilitate the development of social connectedness.

In addition, to living as normal a life as possible, both the interviewees and the caregivers enjoyed spending their time doing activities that are pleasurable in open spaces, such as walking. However, the safety of this activity had to be considered with respect to their cognitive decline. Walking appeared to be a popular activity and this is consistent with previous study findings (Malthouse & Fox, 2014; Robbins, Jones, Birmingham, & Maly, 2013). Walking has been reported as being important for life satisfaction (Åberg, 2008; Åberg, Sidenvall, Hepworth, O’Reilly, & Lithell, 2005), relaxation and relief from social expectation and stress, especially when going out in natural surroundings (Korpela, Hartig, Kaiser, & Fuhrer, 2001). It would appear that, to some extent, people with cognitive impairment can compensate for cognitive losses and manage daily activities (Burgener & Twigg, 2002).

This cyclic process did not stop at the coping strategies. As the condition progressed, caregivers were usually the first people to notice changes in cognitive and physical performance and to come to terms with it, progressing through the cycle again. For those with cognitive impairment, the degree of awareness and readjustment changed with declining cognitive function. Also, as cognitive function deteriorated, so too did physical performance.

6.7 Findings synthesising and inferences

The findings were complex. The primary findings of this study were that, to optimise delivery and engagement in exercise, the factors listed below should be incorporated. These factors are underpinned by the knowledge of the people living with cognitive impairment that exercise is beneficial but that, as cognition declines, the cyclic process described above kicks into play and influences exercise engagement:
• An exercise intervention should allow for individuals to choose whether to participate in a group or individual programme - the differences in internal conflict within individuals who are either at the stage of denial or acceptance will influence the decision to be part of a group or exercise on their own.

• Exercise should be enjoyed and pleasurable - to encourage engagement in the activities they should be fun to do, but at the same time be representative of a ‘normal life’ for them.

• Cognitive stimulation - interviewees recognised the benefits of exercises and wanted exercises that could stimulate cognitive as well as physical function.

• Exercise that has support systems - good support systems are needed which might come from the home, for instance, family members or externally, for instance, group activities which have some element of socialisation.

• Short period of time - due to deterioration both of cognitive and physical function exercises should be simple and short, with repetition of the same exercise because of shorter attention spans. Repetition was necessary to enable learning and retention of new information.

• Complex activities –older adults with mild to moderate cognitive impairment have reduced stability in more complex activities, such as climbing up ladders, turning, moving over different terrains and elevations of footpaths and unforeseen perturbation. However, some degree of complexity of activity should be incorporated into the intervention.

6.8 Strengths and limitations
This current qualitative study only sampled a small number of participants who had previously participated in the psychometric study and thus can only represent the views of those interviewed. Although the sample came mainly from a day care programme specifically organised for older adults with dementia, only five out of nine interviewees were confirmed as having dementia by their general practitioner. The diagnosis of the remaining four interviewees could not be ascertained despite this information being requested from the interviewees’ general practitioners.
The interviewees’ cognitive function ranged from mild to moderately impaired. However, descriptively, the interviewees with mild cognitive impairment were very proactive when providing a response to each interview question. Responses from interviewees with moderate cognitive impairment were more limited and less informative. However, this difference might be because the interviewees did not feel comfortable expressing their feelings to a relative stranger with limited time to develop a trusting relationship. This could be an area of future study.

6.9 Summary

This chapter reported a qualitative study which primarily aimed to establish the potential structure of an intervention for older adults with cognitive impairment to optimise engagement and participation. Based on this study’s findings, six important characteristics of an intervention were identified: 1) It could be an individual- or group-based intervention; 2) exercises should be pleasurable and enjoyable; 3) the need of a support system; 4) due to fatigue, it should be of short duration; 5) it has to include activities to stimulate the brain; and 6) complex activities should also be incorporated. These six factors were deemed important to be incorporated in the complex intervention that I designed- as reported in Chapter 7.

There were also important secondary findings. Older adults with mild to moderate cognitive function have a limited ability to recognise deterioration of cognitive function and physical performance. During the progression of dementia, older adults with mild to moderate cognitive function develop self-regulation and choose to withdraw from the social context as a way to adapt to the changes brought on by the illness. Regardless of which of these adaptation strategies they prefer, older adults with mild to moderate cognitive impairment use practical strategies, for example, noting down in a diary a list of what they should complete for the day and financial support, as a coping mechanisms, alongside support systems, such as their caregivers, to enable them to continue to participate in activities that bring them enjoyment.

The next chapter reports a feasibility study for the intervention I developed to improve postural stability and reduce fall risk for older adults with mild to moderate cognitive
impairment. This intervention was developed based on the findings of the studies reported in Chapters 4 to 6, and on the existing literature. This feasibility study addressed the recruitment process and five areas of interest: acceptability, practicality, adherence, safety and adverse events.
CHAPTER 7: Study 4

Balance Wise Exercise Programme for older adults with self-reported memory loss who live in the community: A proof of concept study

7.1 Introduction

In this chapter I report on the last stage of the development phase of a complex intervention to reduce falls risk and improve postural stability for older adults living with self-reported memory loss. I called this intervention the “Balance Wise” intervention. This play on words encompasses the value of being wise about attending to your balance especially for elders who may have the wisdom that comes with age but who have now reducing cognitive ability or increasing memory loss, without the stigma of incorporating the terms of “cognitive decline / limitation / impairment” or “dementia”.

7.2 Aims of the proof of concept study

This study was a proof of concept case series that primarily aimed to explore the acceptability, practicality, adherence, safety and potential for adverse events of the Balance Wise intervention for older adults with self-reported memory loss, and the viability and success of the study recruitment process. The Balance Wise intervention was delivered either as an individual programme delivered in the home or as a group programme delivered in a community setting. A secondary aim was to evaluate the potential of the intervention to improve postural stability and reduce falls risk.
The primary objectives were to evaluate:

- The acceptability and practicality of delivering the Balance Wise intervention for older adults with self-reported memory loss, specifically comparing group-based with individual-based delivery.
- Adherence to the programme over a 10-week period.
- The viability and success of the recruitment process.
- Safety and adverse events of the intervention.

The secondary objective was to evaluate:

- The potential benefits of the programme with regard to postural stability and falls risk.

7.3 Methods

7.3.1 Study design

This proof of concept case series used a convergent mixed method design (Creswell et al., 2011; Leech & Onwuegbuzie, 2007). In a convergent mixed method design, quantitative data and qualitative data are collected concurrently, analysed iteratively and merged to produce a cohesive model to address the study’s objectives. In this study, the emphasis was on the qualitative data which addressed the acceptability and practicality objectives. The safety and occurrence of adverse events during the Balance Wise intervention were answered by both the qualitative and quantitative data. Quantitative data were used to evaluate adherence, success of the recruitment strategies and the secondary objective of potential health benefits.

The study was approved by University of Otago Human Ethics Committee (Health): H15/073.
7.3.2 Targeted population

As with my previous two studies, due to the challenge in recruitment, the targeted population for this study were older adults with self-reported memory loss and their significant support person (who could be a family/whānau member, a caregiver (unpaid) or a support worker (paid)). The inclusion of a support person was to assist the older adult participants to safely engage in the activities of the exercise programme and to serve as a proxy during the interviews.

7.3.3 Sample size considerations

As this was a proof of concept study, a sample size calculation was not specifically required (Craig et al., 2008; Leon, Davis, & Kraemer, 2011). Based on the experience of recruiting for the prior studies in this thesis, a pragmatic sample size of 10 participants and their significant support people was targeted. The recruitment period was from August 2015 to September 2015.

7.3.4 Participants

Older adults with self-reported memory loss:

Inclusion criteria

- Aged ≥ 55 years old for Māori or Pacific Island or ≥ 65 years old for individuals identifying with an ethnicity other than Māori or Pacific Island. The difference in age classification of ‘older adult’ by ethnic group is considered acceptable due to the reported health status variance among these ethnicities (Blakely et al., 2005).
- Have a diagnosis of dementia or Alzheimer’s disease confirmed by their general practitioner (GP) (permission was gained from participants to contact their GP) or self-reported memory loss with a Mini Mental State Examination (MMSE) score of ≥ 10 (Folstein et al., 1975).
- Able to understand verbal instruction sufficiently to safely undergo postural stability testing, participate in the exercise programme, and take part in an interview.
- Independently mobile for at least 5 metres (with or without walking devices).
• Free from musculoskeletal, cardiac and neurological impairments that would prevent the participant from participating in the testing or the intervention. Consent was gained from participants to get medical clearance and appropriate health information from their GPs to participate in testing and the intervention.

• Living in the community or in a retirement village.

Exclusion criteria
• Participants were excluded if they did not meet the above inclusion criteria.

Support person: Defined as a person who was a family or whānau member, caregiver or support worker who was important and central to the care and support of the participant with self-reported memory loss.

7.3.5 Recruitment

Participants were recruited via public advertising in local newspapers, on TV, radio, public noticeboards, and via meetings and newsletters of the Alzheimer’s Society Otago, Age Concern and the Disability Information Service. On expression of interest, potential participants were sent a study information sheet, a consent form, and a questionnaire. Those willing to participate were asked to contact the School of Physiotherapy Clinical Research Administrator via telephone or email. I then contacted the potential participant to explain the study further, answer any questions, check study eligibility and that the participant was still willing to be involved, following which the first appointment was arranged. Participants were encouraged to bring their support person with them to the School of Physiotherapy Clinic to assist them during the testing procedures. At this first appointment, the participant had an opportunity to ask questions and if still happy to participate was asked to sign consent. Participants were also asked to nominate someone to support them (family / whānau / caregiver / support worker) in the qualitative interview and written consent was gained from this person.
7.4 Delivery of the intervention

As our previous qualitative study (Chapter 6) found mixed opinions on whether the intervention should be group or individually delivered, participants could choose to:
(1) participate in a group exercise programme (held in the School of Physiotherapy) or
(2) work to an individualised, tailored exercise programme delivered at home or at the School of Physiotherapy. The allocation of the participants into either group- or individual-based Balance Wise was therefore by participant choice.

7.4.1 Delivery of Balance Wise

The exercise programme, both group and individual, were delivered by two physiotherapists (DM and myself) to ensure safe delivery. If the participant did not wish the physiotherapist to be present (for example, in the home), to ensure safety participants were asked to undertake the exercises accompanied by their significant support person, who was also appropriately trained. These participants were monitored weekly by telephone.

Participation in the programme, capability to accomplish the group-exercise programme and any adverse events (i.e., pain, discomfort, falls) were recorded at the end of each session in a record book. To optimise adherence, a reminder note for the next class was given after each class. For those who missed a session, a reminder phone call was made and any potential barriers to attendance were discussed.

For the individual-based programme where participants exercised without the physiotherapists present, participants were asked to record the above factors in a provided diary and this information was also collected during the weekly telephone call. To optimise adherence to the home-based exercise programme, I phoned participants at weeks 1, 2, 4 and 8.
7.4.2 Intervention: Group-based Balance Wise

Balance Wise was designed based on the evidenced-based, older adult, fall prevention intervention, the Otago Exercise Programme (OEP) (Campbell et al., 1997; S. Thomas et al., 2010). I modified the OEP to accommodate the current needs of older adults with self-reported memory loss. The modifications were based on the reviewed literature, as well as findings from Chapter 4 and Chapter 6 of this thesis. I kept the exercises prescribed similar to those recommended by the OEP. The new components or the changes that I made are described below.

The delivery of Balance Wise was based on five considerations. Firstly, each participant had medical clearance from their GP stating they were safe to participate in the exercise programme. Secondly, as the original protocol of the OEP was reported as a safe and acceptable exercise programme in older adults with cognitive impairment (Suttanon et al., 2013a), it seemed logical to use this programme as the basis for Balance Wise. Thirdly, as participants may become fatigued quickly and have limited concentration spans, the Balance Wise sessions were kept to a short duration and the exercise intensity was lower than that described in the original protocol of OEP (Chapter 6) (Hill et al., 2009; Suttanon et al., 2013a). The fourth consideration was to include exercises that challenged cognitive function and visual input, and complex motor tasks used in everyday life. Finally, I tried to include exercises that were fun to do.

The full description of the OEP can be viewed at https://www.acc.co.nz/assets/injury-prevention/acc1162-otago-exercise-manual.pdf. Table 7.1 shows the features of the OEP that I modified for the Balance Wise Intervention, based on my findings reported in Chapters 4 and 6. All the exercises and tasks were familiar to participants and the class was organised to be on the same day and at the same time weekly, and to be as simple and short as possible to facilitate optimal learning and engagement. As requested by participants in the qualitative study of Chapter 6, Balance Wise classes were held from 10.00-10.30 am. The intervention was about 30 minutes in duration (the time varied depending on participant ability), and occurred once a week for 10 weeks.
Once a week was not as per suggested by the evidence that emerged from older adults without cognitive impairment (Sherrington et al., 2011). However, this frequency and duration were chosen as other research had indicated that once a week, for 10 weeks participation in the ‘Steady As You Go’ (SAYGo) intervention (a peer-led, group-based version of the OEP for older adults) conducted by Age Concern Otago, improves strength and balance, and reduces the number of hazardous falls (Waters et al., 2011; Wurzer, Waters, Hale, & de la Barra, 2014). The intervention was held in the School of Physiotherapy, thus offering a safe environment.

A variety of equipment was used, all supplied by the School of Physiotherapy. The strengthening exercises targeted the lower limb muscles and sandbag weights for resistance were used, as described in the OEP booklet. The heaviness of the weight provided was based on feedback during the exercise session, depending on ability to manage ten repetitions of a particular exercise. If the participant was not able to finish the required 10 repetitions, the weight was reduced (and vice versa). To progress the strengthening exercise, either the weight was increased, or the number of repetitions was increased and the amount of hand hold support was reduced (Braith, Graves, Leggett, & Pollock, 1993).

Each session began with warming-up in a standing position and comprised activities such as passing a ball (of various sizes and weights) and kicking a ball to promote eye-hand and eye-leg coordination, respectively (Boyke, Driemeyer, Gaser, Büchel, & May, 2008; Niemann, Godde, & Voelcker-Rehage, 2014; Voelcker-Rehage & Niemann, 2013).

Table 7.1 shows the progression of the exercise plan over the 10-weeks of Balance Wise. Balance exercises were conducted in standing and walking. Variations were made to increase the level of difficulty and target the different components of balance; for example, the use of obstacles, a medium-density foam rubber mat (sensory organisation) (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014), a bench and a stepper (which reduces the base of support and dynamic balance) (Hiyamizu,
Morioka, Shomoto, & Shimada, 2012). The participants were also introduced to “eyes open” and “eyes closed” activities; for instance, standing on one leg with eyes closed (sensory organisation) (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014). The backs of chairs were used to give support if participants were unstable whilst doing the activities (Bulat et al., 2007).

Cognitive elements were incorporated into some exercises (Boyke et al., 2008). A dual task activity, for instance counting an amount of money while walking, was used to increase the level of difficulty of the walking task and to stimulate cognitive ability simultaneously (stimulate the executive function) (Muir, Speechley, et al., 2012; Schwenk, Zieschang, Oster, & Hauer, 2010; Silsupadol et al., 2009; Tappen & Hain, 2013). Dual task activity was shown to be one of the strongest factors related to postural instability as described in Chapter 4 (de Andrade et al., 2014; Manckoundia et al., 2006; Pettersson et al., 2005; Suttanon et al., 2012a).

To make the exercise class more enjoyable and pleasurable as described in Chapter 6, music was incorporated as this impacts on mood (Berger & Motl, 2000; Hars, Herrmann, Gold, Rizzoli, & Trombetti, 2013; Hayakawa, Takada, Miki, & Tanaka, 2000). Activities that incorporated free movement, such as playing with a hula-hoop or playing croquet were included, to break-up the potential monotony of using the same exercises throughout the 10 weeks (Shah, Basteris, & Amirabdollahian, 2014). A small party for a Christmas celebration was also organised to promote social interaction.

7.4.3 Intervention: Individual-based Balance Wise

Additional information was provided to participants who chose to have the home-individual-based Wise Balance. Each participant received a prescribed booklet with illustrations and instructions in large print, a set of ankle cuff weights and a record book to monitor the exercises. Additional equipment was given according to level of difficulty of the balance exercises, such as a stepper (dynamic balance) and a medium-density, foam rubber mat (sensory organisation) (Chong et al., 1999; Dickin & Rose, 2004; Gago et al., 2014).
For safety, each activity was first demonstrated to the participant and the significant support person. The support person was instructed to be with the participant during the exercising. If any adverse reaction was experienced, for example, dizziness, chest pain, shortness of breath or muscle pain, the participant was advised to stop the exercise and contact their GP for help (as indicated in the exercise booklet).
<table>
<thead>
<tr>
<th>Content</th>
<th>Week 1-2</th>
<th>Week 3-4</th>
<th>Week 5-6</th>
<th>Week 7-8</th>
<th>Week 9-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warming up and stretching</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throwing and passing</td>
<td>✓ (seated)</td>
<td>✓ (seated)</td>
<td>✓ multiple sizes of ball (standing)</td>
<td>✓ multiple sizes of ball (standing)</td>
<td>✓ multiple sizes of ball (standing)</td>
</tr>
<tr>
<td>Neck stretch</td>
<td>✓ (seated)</td>
<td>✓ (seated)</td>
<td>✓ (standing)</td>
<td>✓ (standing)</td>
<td>✓ (standing)</td>
</tr>
<tr>
<td>Leg stretch</td>
<td>✓ (seated)</td>
<td>✓ (seated)</td>
<td>✓ (standing)</td>
<td>✓ (standing)</td>
<td>✓ (standing)</td>
</tr>
<tr>
<td>Trunk stretch</td>
<td>✓ (seated)</td>
<td>✓ (seated)</td>
<td>✓ (standing)</td>
<td>✓ (standing)</td>
<td>✓ (standing)</td>
</tr>
<tr>
<td>Cognitive elements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counting</td>
<td>✓ - walking and counting</td>
<td>✓ - memorising ingredients for baking a cake</td>
<td>✓ - walking and counting – multiple currency</td>
<td>✓ - memorising a direction</td>
<td></td>
</tr>
<tr>
<td>Memorising</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-eye coordination</td>
<td>✓ - standing small BOS and passing balls into target</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengthening</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee extensor</td>
<td>10 reps, HS</td>
<td>10 reps, HS</td>
<td>10 reps, HS (↑weight)</td>
<td>10 reps, NS</td>
<td>10 reps, NS (↑weight)</td>
</tr>
<tr>
<td>Knee flexor</td>
<td></td>
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<tr>
<td>Hip abductor</td>
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<tr>
<td>Ankle PF</td>
<td>10 reps (seated)</td>
<td>10 reps (seated)</td>
<td>10 reps (seated, ↑weight)</td>
<td>10 reps (seated)</td>
<td>10 reps (seated, ↑weight)</td>
</tr>
<tr>
<td>Ankle DF dorsiflex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Walking</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Walking</td>
<td>Walking around the chair supported</td>
<td>Walking in figure of 8</td>
<td>Walking around the chair and squatting supported</td>
<td>Walking on medium-density foam</td>
<td>Walking with holding full cups of water</td>
</tr>
<tr>
<td>Sideways walking</td>
<td>ST</td>
<td>ST with squatting</td>
<td></td>
<td>Side stepping on bench WS</td>
<td>ST with obstacles – clear the foot from green hurdle</td>
</tr>
<tr>
<td>Exercise</td>
<td>Heel walking</td>
<td>Toe walking</td>
<td>Backward walking</td>
<td>Tandem walking</td>
<td>Backward tandem walking</td>
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<tr>
<td>Heel walking</td>
<td>Heel walking WH</td>
<td>Heel walking</td>
<td>Heel walking</td>
<td>Heel walking</td>
<td>Heel walking</td>
</tr>
<tr>
<td>Toe walking</td>
<td>Toe walking WH</td>
<td>Toe walking NS</td>
<td>Toe walking NS</td>
<td>Toe walking NS</td>
<td>Toe walking NS</td>
</tr>
<tr>
<td>Backward walking</td>
<td>Backward walking WH</td>
<td>Backward walking NS</td>
<td>Backward walking in figure of eight WH</td>
<td>Backward walking in figure of eight NS</td>
<td>Backward tandem walking WS</td>
</tr>
<tr>
<td>Tandem walking</td>
<td>Tandem walking WH</td>
<td>Tandem walking NS</td>
<td>Tandem walking WH</td>
<td>Tandem walking no support</td>
<td>Tandem walking on bench</td>
</tr>
<tr>
<td>Backward tandem walking</td>
<td>Backward tandem walking WS</td>
<td>Backward tandem walking NS</td>
<td>Tandem walking WH</td>
<td>Tandem walking no support</td>
<td>Tandem walking on bench</td>
</tr>
<tr>
<td>Stairs climbing</td>
<td>Stair climbing</td>
<td>Stair climbing</td>
<td>Stair climbing</td>
<td>Stair climbing</td>
<td>Stair climbing</td>
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<tr>
<td>Standing balance</td>
<td>Standing balance</td>
<td>Standing balance</td>
<td>Standing balance</td>
<td>Standing balance</td>
<td>Standing balance</td>
</tr>
<tr>
<td>Sit-to-stand</td>
<td>STS WH</td>
<td>STS NS</td>
<td>STS NS</td>
<td>Hold half STS WS</td>
<td>Hold half STS NS</td>
</tr>
<tr>
<td>One leg stance</td>
<td>1LS WH</td>
<td>1LS NS</td>
<td>1LS NS</td>
<td>ILS medium-density form WS</td>
<td>ILS medium-density form NS</td>
</tr>
<tr>
<td>Stepper</td>
<td>Stepper</td>
<td>Stepper</td>
<td>Stepper</td>
<td>Step up and down WH</td>
<td>Step up and down NS</td>
</tr>
<tr>
<td>Other variations</td>
<td>Other variations</td>
<td>Other variations</td>
<td>Other variations</td>
<td>Other variations</td>
<td>Other variations</td>
</tr>
<tr>
<td>Warming down</td>
<td>Warming down</td>
<td>Warming down</td>
<td>Warming down</td>
<td>Warming down</td>
<td>Warming down</td>
</tr>
<tr>
<td></td>
<td>When sitting, breath in through nose while lifting up UL and breath out through mouth while bringing down the UL to starting position.</td>
<td>When sitting, breath in through nose while lifting up UL and breath out through mouth while bringing down the UL to starting position.</td>
<td>When sitting, breath in through nose while lifting up UL and breath out through mouth while bringing down the UL to starting position.</td>
<td>When sitting, breath in through nose while lifting up UL and breath out through mouth while bringing down the UL to starting position.</td>
<td>When sitting, breath in through nose while lifting up UL and breath out through mouth while bringing down the UL to starting position.</td>
</tr>
</tbody>
</table>

**Notes:** ↑, increase; ILS, one leg stance; BOS, base of support; DF, dorsiflex; DS, double stance EO, eyes open; EC, eyes closed; HS, hold support; NS, no support; PF, plantarflex; reps, repetitions; ST, Side stepping; STS, sit to stand; UL, upper limb; WH, with support.
7.4.4 Intervention Instructors

The Balance Wise was conducted by myself and DM; both qualified physiotherapists (with special scope physiotherapy registration from the New Zealand Physiotherapy Board) who have been working for more than 5 years in the area of falls prevention measures for older adults. During the Balance Wise programme, one was the instructor whilst the other helped participants as required. Before each session, the DM and I met to reflect on the previous session, to discuss the forthcoming session and to modify the programme as appropriate.

7.5 Assessments

Data were collected at three time points: (1) baseline evaluation, (2) during the intervention stage, and (3) 10-week post-intervention. At the 10-week assessment point, quantitative data were collected from participants and then participants were interviewed, all within the same appointment. I collected all quantitative data (at baseline and 10-week assessment points), assisted by DM. During the intervention stage, both the DM and I maintained a clinical diary (detailed later).

Demographic data: Self-reported (or support person proxy reported) demographic data on: age, sex, marital status, ethnicity, education level, medical status, history of falls and medications, as well as self-reported memory loss at baseline were collected. Participants were requested to bring in their list of medications. Confirmation of the diagnosis was determined by sending a “diagnosis confirmation letter” to each participant’s GP.

Cognitive function: The MMSE (Folstein et al., 1975) was used to screen cognitive function of the participants. The method used was the same as described in Chapter 5.
7.5.1 Part 1: Primary outcome measures

Acceptability, practicality, safety and adverse events

Acceptability, practicality and any aspect of safety and any adverse events of the Balance Wise were evaluated qualitatively, guided by the General Inductive Approach described by Thomas (2006) (Thomas, 2006). I conducted face-to-face interviews with each participant and their support person one week after completion of the intervention. The interview was conducted as described in Chapter 6: The interview procedure and data collection. Table 7.2 illustrates the primary questions used in the post-intervention interview. The interview schedule can be viewed in Appendix E.

<table>
<thead>
<tr>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please tell me about the exercise programme you have just completed.</td>
</tr>
<tr>
<td>What motivated you to participate in the programme?</td>
</tr>
<tr>
<td>What were your expectations?</td>
</tr>
<tr>
<td>What were your perceptions of being in the exercise group / exercising alone?</td>
</tr>
<tr>
<td>What would you like to change about the programme to suit you better?</td>
</tr>
<tr>
<td>What would stop you from continuing, or help you to continue, to exercise?</td>
</tr>
</tbody>
</table>

Table 7.2 Primary questions of the post-intervention interview

In addition to the face-to-face interview, the practicality, safety and the recording of any adverse events were also assessed from the clinical notes (as per routine physiotherapy best practice). The clinical notes were recorded by DM and myself. After each session, I recorded particular concerns and comments about the intervention including safety and adverse events as un-structured field notes. For those participants who did the intervention at home, they reported any adverse event in a clinical diary, and this was assessed during the home visit and follow up phone call. The adverse events could have been related to a fall or other muscular pains arising as a consequence from doing the exercises. Recording un-structured field notes is a method used to document important observations including participant comments during fieldwork (Mulhall, 2003). This method allows a more holistic evaluation of the process of the intervention and assessment (Mulhall, 2003).
Adherence

Adherence to the Balance Wise was assessed through class attendance by weekly exercise recording sheets and estimated as a percentage of participants who completed the assessment at baseline (week 1) and follow-up (week 12). Full adherence (100%) was defined undertaking the exercises once a week for the total 10 weeks (McAuley, Courneya, Rudolph, & Lox, 1994; Suttanon et al., 2013a).

Participants who chose to have the individual home-based exercise programme were provided with a booklet and diary in which to record exercises done via a prepared checklist.

Recruitment

The recruitment outcomes included the number of participants recruited per month, time taken for recruitment, recruitment numbers relative to the targeted sample size and percentage of the number who participated out of all who were invited (Leon et al., 2011).

7.5.2 Part 2: Secondary outcome measures

The secondary outcome measures of postural stability and falls risk and were evaluated twice (see Figure 7.1): 1) before the beginning of week 1 (pre intervention), and 2) from week 11 onwards after the 10-week intervention of Balance Wise with the following measures (See paragraph below Figure 7.1 below). I performed all the assessments, assisted by DM. The assessments were conducted in the same sequence for each participant. At baseline height and weight were also measured.
The following outcome measures were chosen based on the findings from the systematic review study in Chapter 4 and the psychometric study reported in Chapter 5, namely, the Physiological Profile Approach (PPA) (Lord et al., 2003), the Timed Up and Go test [basic] (TUG [basic]) (Podsiadlo & Richardson, 1991), the Timed Up & Go test [cognitive] (TUG [cognitive]) (Campbell, Rowse, Ciol, & Shumway-Cook, 2003; Shumway-Cook et al., 2000) and the Step Test (Suttanon et al., 2011). Initially only two outcome measures were to be used: PPA (Lord et al., 2003) and the TUG [basic] (Podsiadlo & Richardson, 1991). Following the concurrent validity study (Chapter 5), the TUG [basic] was altered to include repeating the test so that the person was tested turning both to the right and to the left. These tests were conducted in the same way as described in Chapter 5. The findings of the systematic review (Chapter 4) resulted in two extra outcome measures being included in the current study: the TUG [cognitive] and the Step Test. The systematic review found strong evidence that postural instability in older adults with cognitive decline was associated with the increasing attention demand during a motor task (dual task). This review also found strong evidence that another factor associated with postural stability was static balance. I thus also included the Step Test to assess the ability of static stance on one leg whilst moving the other.
leg, which also compares the use of the dominant and non-dominant leg (Suttanon et al., 2011). The determination of dominant and non-dominant side was based on participants saying which leg they most commonly used to kick a ball. There was no inventory used, I acknowledge this as a limitation of this thesis.

**Measurement of risk of fall**

Two tests were used to categorise participants as being at risk of falls; the PPA and TUG [basic]. With the PPA: I used the cut off point of 5 scale: 
-2 < -1, -1 < 0, 0 < 1, 1 < 2 or 2 < 3 to predict an older adult as being at “low”, “mild”, “moderate”, “marked” and “very marked” risk of having falls, respectively as described by Lord et al. 2003 (Lord et al., 2003). With the TUG [basic], based on the findings of Chapter 5, I used a cut off score of ≥ 13s to indicate increased risk of falling, with a sensitivity of 75% (95% CI: 0.3006, 0.9544) and a specificity of 67% (95% CI: 0.3542, 0.8794) (Shumway-Cook et al., 2000).

**Measurement of postural stability**

Postural stability was assessed with two tests; TUG [cognitive] and the Step test. The TUG [cognitive] assesses the time (duration in seconds) for the participant to stand up from a standard wooden chair, walk 3 meters at their usual pace whilst counting backward in 3s from a randomly selected number between 20 and 10 (for an example 20, 17, 14, 11…), turn, walk back and sit down again in the chair (Campbell et al., 2003; Shumway-Cook et al., 2000). It has moderate test-retest reliability of an ICC of 0.5 in older adults with Alzheimer’s disease (Suttanon et al., 2011). I used a cut off point of ≥15s (Shumway-Cook et al., 2000; Tang, Yang, Peng, & Chen, 2015; Vance, Healy, Galvin, & French, 2015) presented optimal discriminative performance [receiver operating characteristic (ROC) area under the curve (AUC) = 0.82; 95% CI: 0.64, 0.92] to predict risk of falling which was tested in older adults with Parkinson’s disease (Vance et al., 2015) and has a sensitivity and specificity of 87% for correctly predicting falling by community dwelling older adults (Shumway-Cook et al., 2000). The Step Test evaluates dynamic single limb stance (Hill et al., 1996). It involves stepping one foot up onto, then off, a 7.5 cm height block as fast as possible in 30 seconds without
moving the opposite (supporting) foot during the test period. Retest reliability has been found to be good (ICC = 0.8) in older adults with Alzheimer’s disease (Suttanon et al., 2011). Normative data from the stroke population were 0-16 steps in 30 seconds (Hill et al., 1996) whereas the mean score in older adults with dementia was 13-17 steps in 30 seconds (Suttanon et al., 2011). I used a cut off score of 13 to 17 steps in 30 seconds as in this latter study.

7.6 Data analysis

7.6.1 Qualitative data analysis: Acceptability, practicality, safety and adverse events.

The interview data analysis was guided by the General Inductive Approach, as described in Chapter 6: Data analysis. There were five steps in the process of inductive coding: 1) preparation of the raw data; 2) close reading of the text; 3) formation of categories; 4) overlapping categories and un-categorised text; and 5) revision, modification and enhancement of the categories (Thomas, 2006).

The clinical diary and participant diary were reviewed (Sari et al., 2007) and analysed descriptively (Mulhall, 2003). Information related to adverse events was inspected and the number and the percentage of reported adverse events calculated (Davis et al., 2002; Sari et al., 2007; Vincent et al., 2001).

7.6.2 Quantitative data analysis

Quantitative data were analysed using SPSS software for window version 23, IBM Corporation, United States of America. Data were analysed without imputation for missing data because the nature of this study was exploratory and were analysed using intention to treat analysis (McNeish, 2017).

Recruitment, adherence, and adverse event data, as well as age, height, weight, BMI and Mini Mental State Examination Score were all analysed descriptively (mean, standard deviation, range and percentage). The frequency for ethnicity, education,
diagnosis, usage of corrective lenses, usage of hearing aids, history of falls, use of walking aids, medical conditions and number of medication were calculated.

All the data at baseline were tested for normality. As the normality assumption was violated and the sample size was small, the baseline data were compared between group- and individual- based Balance Wise using Mann-Whitney U test; p < 0.05 was considered statistically significant.

Fall risk and functional postural stability were analysed individually for each participant at both pre- and post-intervention time points, to evaluate the within person and within group (individual- and group-based Balance Wise) changes respectively. The difference between them could not be computed as there were insufficient participants in the individual-based Balance Wise (n = 1). Data from the risk of falls and postural stability measures (falls risk index score, TUG [basic and cognitive] tests and the Step Test) were analysed for normality (Portney & Watkins, 2015). The changes in these data were compared using the Wilcoxon Signed Rank Test; p < 0.05 was considered statistically significant.

To measure the potential therapeutic effect of the intervention, effect sizes (r) of the changes in the falls risk and postural stability data were calculated based on the following formula by Clark-Carter (2009) for non-parametric data (Clark-Carter, 2009):

\[ r = \frac{z}{\sqrt{N}} \]

Clark-Carter (2009) suggested that r = 0.1, r = 0.3, r = 0.5 could be considered small, moderate and large effect sizes, respectively (Clark-Carter, 2009).

The differences in performance of Timed Up and Go [basic and cognitive] tests based on turning to dominant and non-dominant leg and Step Test performed by dominant
and non-dominant leg were measured by the Wilcoxon Signed Rank Test; \( p < 0.05 \) was considered statistically significant.

### 7.6.3 Findings synthesising

Table 7.3 illustrates the level of the data merging and the synthesising of the findings of this current study. Data synthesising occurred after all data were collected. The findings from the interviews and diary were merged with the findings from the quantitative results, compared and presented together in order to answer the research objectives. As described earlier, more emphasis was placed on the qualitative findings for answering the acceptability and practicality objectives. The safety and adverse event objectives were answered by both the qualitative and quantitative data. Quantitative data were primarily used to evaluate adherence, success of the recruitment strategies and the secondary objectives of potential health benefits. The findings and results are discussed based on these specific objectives.

<table>
<thead>
<tr>
<th>Aims</th>
<th>Qual. data</th>
<th>Data collection</th>
<th>Quan. data</th>
<th>Data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recruitment</td>
<td>√</td>
<td>-</td>
<td></td>
<td>-Percentage (%) of respondents and participants -Percentage (%) of dropout</td>
</tr>
<tr>
<td>Acceptability</td>
<td>√</td>
<td>-Interview</td>
<td>-Diary</td>
<td>-</td>
</tr>
<tr>
<td>Practicality</td>
<td>√</td>
<td>-Interview</td>
<td>-Diary</td>
<td>-</td>
</tr>
<tr>
<td>Adherence</td>
<td></td>
<td>√</td>
<td></td>
<td>-Attendance record -Weekly exercise checklist (Home-based Exercise)</td>
</tr>
<tr>
<td>Safety and adverse events</td>
<td></td>
<td>-Interview</td>
<td>√</td>
<td>-Percentage (%) of reported incidents</td>
</tr>
<tr>
<td>Potential health benefits</td>
<td></td>
<td>-Diary</td>
<td></td>
<td>-Falls risk score -Postural stability measures</td>
</tr>
</tbody>
</table>

*Notes.* Qual., qualitative; Quan., quantitative.
7.7 Findings and results

Although this current study aimed to compare the two types of delivery of the intervention (individual- versus group-based Balance Wise), this comparison was not possible as only one participant opted for the individual-based exercise intervention. Thus the findings reported below are predominantly from the group-based intervention. However, important findings from the individual-based intervention are highlighted.

There were seven aspects reported in the findings and results section below: 1) Recruitment and response rate; 2) Demographic characteristics of all participants; 3) Acceptability; 4) Practicality; 5) Adherence; 6) Safety and adverse events; and 7) the potential benefits of the programmes.

7.7.1 Recruitment and response rate

*Figure 7.2* reports on the recruitment strategy and the resultant number of participants recruited. Recruitment was took place during August and September of 2015. The total number of respondents were 27. Following despatch of invitations to 12 participants from the previous study (as allowed by my ethical approval) only seven responded, of whom three expressed (25%) interest in the study and four declined (3 = gave reasons, 1 = gave no reason). An advertisement in the Alzheimer’s Society Otago newsletter and on posters on a public noticeboard did not result in recruitment. A presentation at an Alzheimer’s Society Otago seminar attracted one participant, however this individual had to be excluded due to a health issue. An advertisement was then sent via bulk email to members by Age Concern Otago and two responses were received. After 6 weeks of recruitment, a recruitment advertisement was published in the Star Newspaper (a free weekly community newspaper). Seventeen people responded to this advert of whom 11 agreed to participate. Among the respondents, the reasons for declining were: health issues (n = 7), not interested after reading information sheet (n = 4) and work commitments (n = 1).
Following the receipt of their agreement to participate, each participant had baseline balance and fall risks assessments made (n = 15) in the first and second weeks of October 2015. This process included asking for medical clearance and receiving diagnosis confirmation from the participants’ respective GPs. All participants (n = 15) were confirmed to be safe to participate in the exercise programme; however, only seven had a confirmed diagnosis of Alzheimer’s disease by their GP. Only 10 participants underwent the post-intervention assessment. The reasons why five persons were unable to complete the second assessment were health issues (n = 2) and being lost to follow-up (n = 3). The final participant confirmed rate was 55.6% from the total number of potential participants who responded to the invitation to be involved in the study.
Respondents (n = 27), were from:
- Study 2 (Chapter 5), n = 7
- Alzheimer’s newsletter, n = 0
- Age Concern’s bulk email, n = 2
- Poster at public noticeboard, n = 0
- Alzheimer’s Society seminar, n = 1
- Star newspaper, n = 17

Assessed for medical clearance and diagnosis n = 15

Baseline assessment n = 15

Week 1-10: Balance Wise, n = 15
Group Balance Wise, n = 12
Individual Balance Wise, n = 3

Week 11: Follow-up assessment, n = 10
Group Balance Wise, n = 9
Individual Balance Wise, n = 1

Excluded, n = 12
- Not interested, n = 4
- Health issue, n = 7
- Work commitments, n = 1

Diagnosis, n = 7
- AD, n = 3
- Dementia, n = 2
- MCI, n = 2
Unable to confirm, n = 8

Excluded, n = 5
- Health issue, n = 2
- Loss to follow-up, n = 3

*Figure 7.2 Recruitment flow*
7.7.2 Demographic characteristics

Table 7.4 shows participant demographic characteristics at baseline. Table 7.5 shows the characteristics of the ten participants and their support person (by pseudonym) who completed 10 weeks of Balance Wise.

Three female and one male support persons who were spouses and one ex-wife also participated in this study. The mean (SD) age of the support persons was 71.5 (2.7) (range 69 – 76) years. Caregiver medical conditions included osteoarthritis and back pain. Four support persons participated in the interview, but only three support persons actively exercised with the person they supported.
Table 7.4 Characteristics of participants at baseline

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group-based, n = 12</th>
<th>Individual-based, n = 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Range</td>
</tr>
<tr>
<td>Age, years</td>
<td>76.8 (5.6)</td>
<td>67-87</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>7, 58</td>
<td></td>
</tr>
<tr>
<td>Height, m</td>
<td>1.67 (0.1)</td>
<td>1.53-1.81</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>75.88 (15.9)</td>
<td>45.50-93.50</td>
</tr>
<tr>
<td>BMI</td>
<td>22.57 (4.2)</td>
<td>15.00-29.00</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealander, n (%)</td>
<td>12 (100%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Education:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or college, n (%)</td>
<td>5 (42%)</td>
<td></td>
</tr>
<tr>
<td>Vocational or trade qualification, n (%)</td>
<td>3 (25%)</td>
<td></td>
</tr>
<tr>
<td>Tertiary diploma or degree, n (%)</td>
<td>3 (25%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alzheimer’s disease</td>
<td>3 (25%)</td>
<td></td>
</tr>
<tr>
<td>Fronto-temporal lobe dementia</td>
<td>1 (8%)</td>
<td></td>
</tr>
<tr>
<td>MCI</td>
<td>1 (8%)</td>
<td></td>
</tr>
<tr>
<td>Unable to confirm diagnosis</td>
<td>7 (58%)</td>
<td></td>
</tr>
<tr>
<td>MMSE</td>
<td>25 (4)</td>
<td>18-30</td>
</tr>
<tr>
<td>Corrective lenses, n (%)</td>
<td>11 (92%)</td>
<td></td>
</tr>
<tr>
<td>Hearing aids, n (%)</td>
<td>4 (33%)</td>
<td></td>
</tr>
<tr>
<td>History of falls:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No falls, n (%)</td>
<td>9 (75%)</td>
<td></td>
</tr>
<tr>
<td>One or more falls, n (%)</td>
<td>3 (25%)</td>
<td></td>
</tr>
<tr>
<td>Use walking aids, n (%)</td>
<td>12 (100%)</td>
<td></td>
</tr>
<tr>
<td>Medical conditions:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>5 (42%)</td>
<td></td>
</tr>
<tr>
<td>Lung disease, n (%)</td>
<td>1 (8%)</td>
<td></td>
</tr>
<tr>
<td>Depression, n (%)</td>
<td>2 (17%)</td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal, n (%)</td>
<td>2 (17%)</td>
<td></td>
</tr>
<tr>
<td>Others*, n (%)</td>
<td>4 (33%)</td>
<td></td>
</tr>
<tr>
<td>No. of medications</td>
<td>0-11</td>
<td></td>
</tr>
</tbody>
</table>

Notes. MCI, mild cognitive impairment; MMSE, Mini Mental State Examination; SD, standard deviation.

* high cholesterol and cataract
Table 7.5 Characteristics of participants who completed 10 weeks Balance Wise and their support person

<table>
<thead>
<tr>
<th>Participant with confirmed diagnosis</th>
<th>Support person</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G/I</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td>G</td>
<td>Alia</td>
</tr>
<tr>
<td></td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>74</td>
</tr>
<tr>
<td>G</td>
<td>Zain</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>G</td>
<td>Dane</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>G</td>
<td>Sue</td>
</tr>
<tr>
<td></td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>81</td>
</tr>
<tr>
<td>G</td>
<td>Wilson</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>87</td>
</tr>
<tr>
<td>G</td>
<td>Mark</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>I</td>
<td>Julie</td>
</tr>
<tr>
<td></td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>71</td>
</tr>
<tr>
<td>G</td>
<td>Leslie</td>
</tr>
<tr>
<td></td>
<td>F</td>
</tr>
<tr>
<td>G</td>
<td>Wood</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>74</td>
</tr>
<tr>
<td>G</td>
<td>Hansen</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>76</td>
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<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>Age (yr)</th>
<th>MMSE score</th>
<th>Med. Cond.</th>
<th>Pseudo Name</th>
<th>Age (yr)</th>
<th>Med. Cond.</th>
<th>R.</th>
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<tr>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>G</td>
<td>M</td>
<td>74</td>
<td>21</td>
<td>1</td>
<td>Joanna</td>
<td>70</td>
<td>0</td>
<td>Wife</td>
</tr>
<tr>
<td>G</td>
<td>M</td>
<td>82</td>
<td>24</td>
<td>2</td>
<td>NA</td>
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<td>NA</td>
</tr>
<tr>
<td>G</td>
<td>F</td>
<td>81</td>
<td>30</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>G</td>
<td>M</td>
<td>87</td>
<td>28</td>
<td>3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>72</td>
<td>24</td>
<td>2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>I</td>
<td>F</td>
<td>71</td>
<td>25</td>
<td>0</td>
<td>Brown</td>
<td>71</td>
<td>0</td>
<td>Husband</td>
</tr>
<tr>
<td>G</td>
<td>F</td>
<td>71</td>
<td>25</td>
<td>0</td>
<td>NA</td>
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<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>G</td>
<td>M</td>
<td>74</td>
<td>17</td>
<td>7</td>
<td>Cole</td>
<td>69</td>
<td>1</td>
<td>Ex-wife</td>
</tr>
<tr>
<td>G</td>
<td>M</td>
<td>76</td>
<td>21</td>
<td>3</td>
<td>Megan</td>
<td>76</td>
<td>1</td>
<td>Wife</td>
</tr>
</tbody>
</table>

Notes. G, group-based Wise Balance; I, Individual-based Wise Balance; Med. cond., Number of Medical Conditions; MMSE, Mini Mental State Examination; NA, not available; R., relationship; yr, year.

*Diabetes, hypertension, arthritis, knee and hip replacement and respiratory problems, and back pain.

7.7.3 Acceptability, practicality, adherence and safety and adverse events of the overall programme design.

Figure 7.3 illustrates the link between the themes, subthemes and categories to answer acceptability, practicality, safety and any adverse events with respect to the programme design. Ten participants and four support persons were interviewed. Participants and their support persons were interviewed together.

Qualitative analysis of the post-intervention interviews resulted in the identification of three themes. The themes were refined further into subthemes and categories.
Figure 7.3 Linkage between themes, subthemes and categories.

In Figure 7.3, the bold words within blue-white boxes represent the three primary themes: ‘decision making’, ‘comprehension’ and ‘perceived benefits’. The blue boxes represent the subthemes of the themes: ‘awareness’, ‘health belief’, ‘support system’, ‘perceived stability’ and ‘suggested intervention alterations’. Green boxes represent the categories under the subtheme ‘support system’: ‘peer support’, ‘instructors’, ‘adaptability and safety’, and ‘accessibility’. The blue dotted line represents the process that happened between pre-research and research.

‘Comprehension’ and ‘perceived benefits’ were the two themes that primarily answer the study’s aims of exploring the feasibility of the intervention in terms of acceptability, practicality, adherence and safety and adverse events. The theme of ‘decision making’ was deemed important to present first, as it provides a contextual background to the
other two themes. To make sense of the process of linkage between themes, the description of the findings below was followed in chronological order from a process of pre-research to research.

The theme ‘decision making’ illustrated the initial process of making a decision as to whether the intervention was acceptable to join or not. Having decided to join, it was quite clear that participants continued to deliberate as to whether to remain in the intervention, or not, over the full 10 week course.

The acceptability of the intervention was strengthened by the second theme, ‘comprehension’. Increasing ‘awareness’ of participants of their postural stability and cognitive function helped them to comprehend and understand the intent of the programme better and the ‘perceived benefits’ of it. ‘Awareness’, then strengthened their resolve to continue with the intervention. The theme ‘perceived benefit’ was explained by three subthemes: ‘support system’, ‘perceived stability’ and ‘suggested intervention alterations’. The participants’ perceived that one of the key values of the intervention was the support system accompanying it. Support came from five sources, the five categories comprising this subtheme, namely: ‘peer support’, ‘instructors’, ‘adaptability and safe’, and ’accessibility’. They were also aware of the benefits of the intervention as they perceived that it improved their postural stability (‘perceived stability’). However, participants had ‘suggested intervention alterations’ to increase the benefits of the intervention that might promote adherence and acceptance of it.

Each of these themes, with their subthemes and categories are discussed further below.

**Decision making**

‘Decision making’ was an important theme as it spoke to the acceptability of the intervention. In the first instance, participants had to decide whether the intervention was acceptable enough for them to participate. Their initial expectation was that the intervention would help to improve postural stability, however many also held the belief that it would also help improve their memory. As they continued with the
intervention over the ten weeks, they continued to deliberate as to whether the perceived benefits of attending the classes were worth the effort; i.e., did it continue to be an acceptable intervention, and this influenced adherence to the intervention. This decision making was influenced by their ‘awareness’ of, and ‘health belief’ in, their intervention. Similar deliberation was also reported by the support person.

**Awareness**

Participants said that they initially decided to join the intervention as they thought it would help their declining memory. Most interviewees were concerned and worried about their memory, that it was gradually deteriorating, especially their short term memory. The exercise programme appeared to offer hope to battle the deterioration of their memory. For instance Leslie mentioned during the interview ‘I was looking for exercises that I could do which would be beneficial for my balance and memory’. With continued involvement in the intervention, there was a growing awareness that the intervention could improve their physical performance, particularly their postural stability while at the same time they would be using executive function - focus while doing a task. As one of the interviewees explained:

I used to go down stairs sideways, one foot at a time. But now I go down normally, but it requires more concentration now than it used to. So from that point of view, yes. I suppose I always have concentrated, but now I realise I must concentrate a bit more.

(Wilson)

The support person was also aware that the person that they cared for had a deteriorating memory, including a reduction in reasoning. For example, one support person shared a life experience when instructing the person whom she cared for:

Well, I have learnt that if I want [Wood] to do something, I will just say one thing at a time. I will say “Would you mind popping upstairs
and getting my handbag”. As long as it is [short and simple], he can remember that. (Cole-support person)

Health beliefs

The acceptability of the intervention was strengthened by participants’ belief that it would be beneficial for them. For one participant, the decision to take part in the programme was determined by the belief that the medical system facilitated health benefits and thus empowered a person to assist themselves. This belief system developed from previous positive experiences of receiving treatments from health care professionals. As Sue acknowledged: “The medical system has always been very helpful to me, but it is up to me too, to do things for myself, that is what I believe”.

For another participant, the internal belief that one has to exercise hard to get the benefit from exercises, drove him to try and get the most out of the exercise classes:

If you get on the bicycle, and put the load on, pretending [cycling] up hill, putting stress on [muscle], that’s good. The same [thing] when you do stepping. You do the stepping [similar to walking] up hill, because of the slope, it [uses a lot of] energy, and you have to work at it. No pain, no gain. (Dane)

For another participant, her internal belief was to only do exercises that she was “comfortable” doing without stressing too much trying to do something that she could not. Although the amount of effort applied to the exercises might have differed between participants, they all still held the health belief that participating was beneficial, thus highlighting the intervention’s acceptability.

Joana, who supported Zain (who did home-based exercises) had a similar comment to make:
I thought ‘well, we’ll give that a try.’ It’s reasonable to say that [Zain] doesn’t make those decisions. I do, to try and keep him going. And since then walking’s got a bit easier for you, hasn’t it, for you, since you’ve been coming to the programme. (Joana-support person)

In this example, Zain, who had a cognitive limitation, needed surrogate decision making.

**Comprehension**

It appeared that most participants were able to grasp the concept and purpose of the activities in Balance Wise (for example, activities to improve the use of the sensory system or those that were aimed to increase muscle strength), even for the multi-tasking activity that involved “calculation and concentration”. For instance Wilson said: ‘I can understand the theory behind it, if you’re thinking of something else, in your head, you’re not thinking of where your feet are going’. (Wilson)

However, unsurprisingly, a few participants found the latter activity to be quite challenging. These tasks demonstrated to participants that cognitive skills, which they had been unconsciously competent in previously, they were now unconsciously incompetent at. As one participant stated: ‘I found [the cognitive stimulation activity was] quite difficult. I had forgotten about that one. Yes, I found [it was] quite challenging, I had never done anything like that before, it was new, and interesting.’ (Sue)

The support persons interviewed also said they could see the purpose of the whole programme, that it had exercises that focussed on both cognitive and physical limitations, which was good.

…. because you’ve got to think - they’ve got to try and think about what they’re doing. And I think it might help coordination, it might
help, well, balance in particular, I think that’s what the biggest problem is for older people. They lose their balance, and I think that meant, yeah, those exercise programmes on the walkways and things I think would probably help quite significantly for quite a few of them. (Joana-support person)

For this reason, Joana was very supportive of Zain to continue attending the class.

**Perceived benefits**
Balance Wise was viewed as beneficial by both participants and support persons and this spoke to its acceptability. Within this theme were two subthemes (‘support system’ and ‘perceived stability’) that described in more detail how and why Balance Wise was beneficial.

**Support system**
Support system was viewed as one of the important characteristics of Balance Wise that linked to decision making and acceptability. There were four support systems that were deemed important for participants: peer support, instructors’ support, adaptability and safety and accessibility.

**Peer support**
Participating in the programme led to the development of social capital. The attendant support persons (spouses, one ex-wife and friends) became integral to the participants’ support system. The support system that was built via the socialising occurring during the intervention was continued outside the intervention. The participants expressed that socialising gave companionship to the members who lived alone, delivered a sense of empowerment and motivation between members to keep going and keep active as a way to combat future disability. This support system was the basis for generating the discipline to continue exercising on a weekly basis.
Well, I enjoy the social side of it. I [found the activities were] pretty easy. [I] enjoyed and [I] like the people, very much. [The group had] a great mixture of both in personalities and the [cognitive] stage they’re at. (Hansen)

Further, the support person could see the benefits of the class either from participating in the exercises themselves, or due to the short period of relief away from the stress of being a support person. Indeed, the support persons also found that the Balance Wise programme gave them an opportunity to make new friends.

I really like the class; I met some nice people. A couple of really nice women, that I think they have asked for my contact details. I think we will keep in touch. So that was a good aspect of it. (Cole-support person)

**Instructors’ support**

All participants and their support persons valued the support of the exercise instructor. They recognised that some participants required more attention than the others, as Alia said: ‘So yes, but it’s been good seeing how you handle other people. And trying to set them on the right road if they’re not doing it correctly– that’s a difficult one. [A] challenging one, actually.’ (Alia)

In particular, participants highly valued: (1) the instructor’s clear instructions accompanied by demonstrations and (2) having two instructors increased confidence as well as safety. Megan (support person) explained:

I think sometimes clear explanation beforehand, with a visual demonstration. But that might be just me, I don’t know. I think it’s good when there’s two of you because one of you is watching while the other one’s demonstrating, I think that’s probably very good, because you can see who needs a bit of help. (Megan-support person)
**Adaptability and safety**

Participants said that Balance Wise was “easy” to follow and something they could adapt and include into their daily lives, so that, the exercise was not only something that could be done in the School of Physiotherapy but could be “done every day” at home. For example, Sue reported that she now did the one leg standing exercise that she learnt from Balance Wise at home while she watched television. Similarly, Mark and Julie said they adapted the exercises that they had learnt from the exercise programme while doing activities outdoors. Hansen said he counted a handful of money whilst walking. Julie, the only person who participated in the home-based programme mentioned:

> I think I [am aware] and I have to concentrate a little bit more on my balance. For instance, recently at Papatowai, going down [the trail] was very steep and [Jim] said ‘remember your exercise’, and I [walked] down without any problems. It was a real test. (Julie)

Wilson felt that, whilst most participants managed the exercises reasonably well, for some, the exercises could be a little more strenuous, especially those that involved dual tasking; for instance, simultaneous cognitive and postural stability tasks. Wilson did acknowledge though, that the exercises had to be safe.

> You have to think up something a little bit more strenuous on the mind or strenuous on the feet, to be able to dissociate the two, so that you did tend to lose your balance, although you can’t have people falling down all over the place. (Wilson)

**Accessibility**

Transportation to the School of Physiotherapy was not reported as a barrier to attendance. Most participants were able to catch a bus to and from the School. A few participants came by car and parking did not appear to be an issue. However, Julie,
chose to do the individual home-based exercise programme due to the time it took to travel to the School of Physiotherapy. She explained that:

Doing it in a group was probably more fun, but I was a bit restricted with time, in that I’m doing a lot of other things as well. And I just felt if I did it at home, it would be more conscientious effort on my part. Without wasting time coming and going. (Julie)

Participants were aware that they were part of a research study and were thus conscious of the added need to give an apology if they could not attend. They also acknowledged that it was their responsibility to attend Balance Wise and thus respect the other members who participated. Other possible barriers to attendance that participants mentioned, but were not considered major barriers, were inclement weather, challenges in getting ready to attend on time and ill health. For one participant, however, the internal conflict he had with himself was a barrier to attendance. As his caregiver explained, he sometimes was reluctant to attend, but for no specified reason:

Well, he just didn’t really want to participate, but I encouraged him to continue the course. I say if you start something you [have to] finish it. But it worked out all right in the end. (Megan-support person).

**Perceived stability**

Quite clearly participants found value in the intervention as a means of improving their postural stability. As Dane said:

I think the [activities that] associated with balance. There were mainly- some of those were on foam, and some were without. I think the balance [activities], it’s not only [that activity] involving the muscle, [it also involving] the brain and the sensory organs. That’s what I think is the most interesting part. (Dane)
Sue reported that she had not tripped once since starting in the intervention. Wilson said that he was now able to walk downstairs “normally” even though he still needed to concentrate. Leslie said that the intervention had “increased her confidence”, that the habit of concentration had now become automatic and that she frequently reflected back on what was learnt from the intervention whilst walking down stairs, an activity she was previously afraid to do. Mark told how his general practitioner was “pleased he was participating in the exercise programme” and encouraged him to “continue” to do so. Sue also spoke of the benefits of the intervention:

Well, I know already that [exercise] helped with my walking, my balance, and [while I am] getting dressed. I have mentioned to you that, I can now stand on one leg and put my trousers on. (Sue)

**Suggested intervention alterations**

Although, generally, Balance Wise was an acceptable exercise programme to participants, they did suggest a few improvements and these related to the components of the exercises, mostly the balance between repetition and variation (e.g., exercises for upper limb and for co-ordination, activities related to dual tasking), and the duration of the exercises programme. Wilson expressed

I mean throwing somethings to one [and] another, but it’s probably a little bit lacking in [the exercise programme], [such as] an activity that involves coordination between individuals rather than coordination between hand and eye, in one individual. But coordination between- in other words, the unexpected, dealing with the unexpected. (Wilson)

It appeared that participants with memory issues had greater difficulty in completing dual task activities. While some participants felt that a multi-task activity was easy, it was not for others.
You are thinking as well as physically doing something, and you [are] combining the two. You know, could have much better if I would [have] been counting forward, but that would be too easy, wouldn’t it? (Leslie)

Some participants liked how Balance Wise had a variety of exercises, although Cole (support person) felt that there should be a balance between variety and repetition. She did recognise that this would be challenging to achieve; that something is more easily remembered by doing it frequently, but at the same time variation enhanced enjoyment.

It is a hard [to achieve] balance, between systematically, repetitively, doing the same thing, and making it challenging and different. I think there was a balance there, but it needs to have a pattern for people who can pick that up and realise [each of the exercise]. It is because they [have difficulties in] memory, but they will still remember [the exercises] as they go, [and] at the same time you have to stimulate their interest. (Cole-support person)

Although most participants were satisfied with the short duration (30 minutes) of the sessions, many felt they could have been longer by about 15 – 30 minutes. Participants who were satisfied with the short duration of the exercise sessions reported that they did not feel they were tired at the end. Megan (support person) acknowledged that increasing the duration of sessions could increase fatigue levels, but that this could be mitigated by frequent rest periods.

He gets tired easily and he [takes a] rest most [of the] afternoons, because [he needs to] concentrate [while doing] something on his own, [such as] a code cracker and he rests for a while before continue doing his task. So I guess, if [the exercise] is an hour, there’s [should] be have to be spaces for rest where there was sitting time. (Megan-support person)
A few support persons expressed concern that the exercises should be individualised to the person’s ability; that a mixed level of ability in the class minimised the benefits. One support person felt that the group-delivered Balance Wise was not suitable for a person who had significant cognitive impairment because of the limitation in understanding the instructions, and for this support person, they did not think the group-based Balance Wise offered much to the person they supported. To overcome this limitation of the intervention, she suggested that the skills and exercises provided in the classes should be determined by ability level. For instance ‘[when you have] a big enough cohort, perhaps split [it] into two groups, one for the less and one for the more mentally challenged people, according to the mental tests that you do at the start’.

(Cole-support person)

While some participants found group-based Balance Wise was “pleasant” and “fun”, others participants recognised that they should be encouraged to do more exercise at home. In the other words they accept the benefit of doing individual exercise as well.

7.7.4 Practicality

The practicality of the intervention was assessed from the clinical notes (as per routine physiotherapy best practice) recorded by the intervention instructors, DM and myself, and from the clinical diary recorded by those participants who were doing the intervention at home. The diary’s data were compared with the interview findings, resulting in the identification of themes related to practicality.

Both instructors also completed a diary. They reported in their diaries on both the practicality of the assessment and the practicality of the programme. The comments made in these diaries relating to the assessment process were: two participants had difficulty understanding the instructions; three participants had difficulty in completing the assessment; and one participant had a fear of falling. Comments related to the intervention were: three participants had difficulty with the exercises; and one participant was reluctant to attend the programme. Noted in the diaries were participants’ comments about the intervention: two participants said they were more
confident with their balance; one participant reported weight loss; and one participant had received encouragement from their doctor to continue the exercise programme. In terms of feasibility of conducting the exercise programme, I reported having difficulties in handling two participants whereas DM reported no difficulties. The aforementioned difficulties were related to one participant not being able to follow instructions and understand what he had to do, and another participant who was very anxious.

7.7.5 Adherence to the 10 week programme

Group-based Balance Wise

Twelve participants agreed to participate in the group-based exercise programme and all completed baseline assessments (100%). The baseline assessments lasted 30-40 minutes.

Two of the 12 participants completed ten classes (100%), four participants attended nine classes (90%), three participants attended eight classes (80%), one participant each attended six (60%), four (40%) and one class (10%). The participants who had only attended the one time and the four times were lost to follow-up (at week-2 and week-5) without any explanation. The other participants notified me by telephone, email or after a session, if they unable to attend the next session. There were various reasons for non-attendance including pre-planned vacations and ill health (for example, leg pain not associated with the exercises). One participant reported that she did not attend one session as she could not remember where the School of Physiotherapy was so she returned home.

One participant was unable to be assessed post intervention because they failed to come back for assessment even after two follow-up telephone calls. Thus nine (60%) participants completed the second assessment which lasted 40-60 minutes. Twenty minutes of this was allocated for the interview session.
Three participants were accompanied by their support persons in the class. These support people joined in by doing the exercise sessions. All these three also helped “their” participant in terms of instruction and movements that were found to be difficult to follow.

**Individual and home-based Balance Wise with instructor**

Three participants agreed to attend the individual, home-based intervention. All participants completed baseline assessments (100%). The baseline assessment lasted 30-40 minutes. The reasons for attending the individual home-based exercise intervention and not the group programme were: (1) independence in choice as to when, and which day, to exercise, (2) the distance between the participant’s home and the School of Physiotherapy, and (3) other unspecified commitments. Two participants attended individual-based Balance Wise at the School of Physiotherapy supervised by DM and myself. One did the programme at home with their caregiver after I instructed them in what to do.

Only one participant (of the individual-based programme participants) completed 10 sessions. One participant completed 8 out of 10 sessions at the School of Physiotherapy; they missed the other 2 sessions due to a pre-planned vacation. One participant stopped attending after session 2 due to a health-related (unspecified) problem and was not assessed post-intervention. Thus, only two participants in the “individual-based Balance Wise” completed the post-intervention assessment. However, the data for one of the participants, who had completed post-intervention, were excluded from the data analysis as it was discovered later this person had Ménière’s disease which overly affected her balance. Thus, there was only one participant for data analysis.

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6 Older adults with memory loss whom the support person supports.
7.7.6 Safety and adverse events with Balance Wise

A diary was provided to participants over the December holiday break so that both the group-based and individual-based participants could continue their exercises at home and record what they did. Four participants returned the diary, three from the “group” exercise and another one from the “individual” exercise programme. However, only two of these diaries were completed with exercises notes and comments.

The DM and I recorded any adverse events that participants reported during the classes, and these were: feeling unstable while performing exercise (n = 2, 20%), feeling depressed (n = 2, 20%), leg pain as the consequence of a previous leg injury due to traffic road accident (n = 1, 10%) and weight loss (n = 1, 10%). Three participants reported finding the exercises quite challenging.

Minor complaints

Safety and adverse events are critical issues to address in developing a health related intervention. No falls or other serious adverse events related to Balance Wise were reported during the study period. Minor complaints relating to muscle soreness were reported but eased or resolved the subsequent day. One participant even commented specifically about the safety of the class “You have got a chair near you, there is no reason why you actually collapse, unless you get suddenly lack of blood to the head”. The use of chairs to increase the level of safety during exercises was considered by participants to be good.

7.7.7 The potential benefits of the programme relating to falls risk and postural stability

Table 7.6 shows the falls risk and postural stability performance at baseline. There were no significant differences (p > 0.05) for all variables except the TUG [cognitive] while turning (p = 0.30) to dominant leg and the Step Test (dominant leg = 0.043, non-dominant leg = 0.042).
Table 7.6 The findings of falls risk and postural stability performance at baseline

<table>
<thead>
<tr>
<th>Measure</th>
<th>Group based, n = 12</th>
<th>Individual based, n = 3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>Interquartile range</td>
<td>Median</td>
<td>Interquartile range</td>
</tr>
<tr>
<td>PPA falls risk</td>
<td>0.78</td>
<td>2.02</td>
<td>1.75</td>
<td>-</td>
</tr>
<tr>
<td>TUGND&lt;sup&gt;a&lt;/sup&gt;(s)</td>
<td>9.87</td>
<td>3.37</td>
<td>19.34</td>
<td>-</td>
</tr>
<tr>
<td>TUGD&lt;sup&gt;a&lt;/sup&gt;(s)</td>
<td>10.08</td>
<td>4.20</td>
<td>17.97</td>
<td>-</td>
</tr>
<tr>
<td>TUGcogND&lt;sup&gt;a&lt;/sup&gt;(s)</td>
<td>10.86</td>
<td>5.56</td>
<td>23.03</td>
<td>-</td>
</tr>
<tr>
<td>TUGcogD&lt;sup&gt;a&lt;/sup&gt;(s)</td>
<td>12.96</td>
<td>6.22</td>
<td>23.32</td>
<td>-</td>
</tr>
<tr>
<td>Step Test ND</td>
<td>21.5</td>
<td>9.75</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Step Test D</td>
<td>20.5</td>
<td>7.25</td>
<td>12</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes. AP, antero-posterior; D, dominant leg; EO, eyes open, EC, eyes closed; deg, degree ML, medio-lateral; mm, millimetre; ms, milliseconds; ND, non-dominant leg; kg, kilogram; s, second; TUGD, Timed Up and Go test turn to dominant leg; TUGND, Timed Up and Go turn to non-dominant leg.

<sup>a</sup> lower score indicates better score. z, Mann-Whitney U Test.

<sup>*</sup> significant difference, p < 0.05 (2-tailed)
Falls risk and postural stability: Pre-post data analysis

Table 7.7 illustrates that there was no significant difference ($p > 0.05$) in the overall PPA falls risk score ($p = 0.24$), TUG [cognitive] turn to non-dominant leg ($p = 0.17$), turn to dominant leg ($p = 0.65$) and Step Test on non-dominant leg ($p = 0.26$) between baseline and post intervention (10 weeks of Wise Balance). Only three outcomes demonstrated significant changes post-intervention: TUG [basic] turn to non-dominant leg ($p = 0.01$) and dominant leg ($p = 0.01$) and number of steps in Step Test on the dominant leg ($p = 0.01$).

Table 7.7 illustrates the effect size of the tests. Small ($r = 0.1$) and moderate ($r = 0.3$) effects were noted, except in the 3 significant items that had large effect size ($r > 0.5$). These three items were: time completed on TUG [basic] turn to dominant and non-dominant leg side and Step Test on dominant leg.
Table 7.7 The findings of falls risk and postural stability at baseline and at week 11 post Balance Wise

<table>
<thead>
<tr>
<th>Measure, unit</th>
<th>Baseline</th>
<th></th>
<th></th>
<th>Week 11</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>Interquartile range</td>
<td>Median</td>
<td>Interquartile range</td>
<td>z</td>
<td>p</td>
</tr>
<tr>
<td>PPA falls risk</td>
<td>1.00</td>
<td>1.86</td>
<td>0.26</td>
<td>0.86</td>
<td>-1.17</td>
<td>0.24</td>
</tr>
<tr>
<td>TUG[B]ND(^a), s</td>
<td>10.11</td>
<td>3.61</td>
<td>8.89</td>
<td>2.79</td>
<td>-2.60</td>
<td>0.01*</td>
</tr>
<tr>
<td>TUG[B]D(^a), s</td>
<td>9.94</td>
<td>3.38</td>
<td>8.59</td>
<td>2.96</td>
<td>-2.50</td>
<td>0.01*</td>
</tr>
<tr>
<td>TUG[C]ND(^a), s</td>
<td>12.75</td>
<td>5.64</td>
<td>10.18</td>
<td>8.22</td>
<td>-1.38</td>
<td>0.17</td>
</tr>
<tr>
<td>TUG[C]D(^b), s</td>
<td>13.58</td>
<td>4.99</td>
<td>12.11</td>
<td>14.40</td>
<td>-0.46</td>
<td>0.65</td>
</tr>
<tr>
<td>Step test ND(^b)</td>
<td>23.00</td>
<td>10.50</td>
<td>26.00</td>
<td>8.00</td>
<td>-1.13</td>
<td>0.26</td>
</tr>
<tr>
<td>Step test D(^b)</td>
<td>21.50</td>
<td>7.25</td>
<td>26.50</td>
<td>9.00</td>
<td>-2.56</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

Notes: B, basic; C, cognitive; CI, Confidence Interval; s, second; D, dominant; ND, non-dominant

TUG, Timed Up and Go.

\(^a\)lower score indicates better score; \(^b\)number of steps

z, Wilcoxon Signed Rank Test.

r, effect size

*significantly difference, p < 0.05 (2-tailed)
Individual falls risk score measured by the Physiological Profile Approach

Table 7.8 reports the falls risk score for each participant as measured by the PPA falls risk score. The five points of the cut off scale used were: -2 < -1, -1 < 0, 0 < 1, 1 < 2 or 2 < 3 to predict an older adult as being at “low”, “mild”, “moderate”, “marked” and “very marked” risk of falls, respectively, as described by Lord et al. 2003 (Lord et al., 2003).

Table 7.8 Falls risk score at baseline and at 10 weeks measured by the Physiological Profile Approach

<table>
<thead>
<tr>
<th></th>
<th>MMSE</th>
<th>Fall risk score</th>
<th>Status</th>
<th>Fall risk score</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>28</td>
<td>1.72</td>
<td>Marked</td>
<td>0.76</td>
<td>Moderate</td>
</tr>
<tr>
<td>P2</td>
<td>21</td>
<td>0.96</td>
<td>Moderate</td>
<td>1.42</td>
<td>Marked</td>
</tr>
<tr>
<td>P3</td>
<td>24</td>
<td>0.04</td>
<td>Moderate</td>
<td>0.25</td>
<td>Moderate</td>
</tr>
<tr>
<td>P4</td>
<td>30</td>
<td>2.33</td>
<td>Very</td>
<td>2.1</td>
<td>Very</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marked</td>
<td>-0.13</td>
<td>Marked</td>
</tr>
<tr>
<td>P6</td>
<td>24</td>
<td>0.6</td>
<td>Moderate</td>
<td>0.26</td>
<td>Moderate</td>
</tr>
<tr>
<td>P7</td>
<td>25</td>
<td>1.25</td>
<td>Marked</td>
<td>0.13</td>
<td>Moderate</td>
</tr>
<tr>
<td>P8</td>
<td>29</td>
<td>-0.97</td>
<td>Mild</td>
<td>-0.60</td>
<td>Mild</td>
</tr>
<tr>
<td>P9</td>
<td>18</td>
<td>2.26</td>
<td>Very</td>
<td>0.21</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marked</td>
<td>0.53</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Notes. MMSE, Mini-Mental State Examination, P, participant.

In Table 7.8 it can be seen that, at baseline, falls risk status varied between participants. Although not statistically significant, four participants improved their falls risk score, two participants had an increased falls risk and for four participants there was no change in falls risk.

Comparison of the performance of Timed Up and Go test between turning to dominant and non-dominant side and performance of Step Test between dominant and non-dominant leg

Table 7.9 illustrates the comparison of the performance of TUG [basic and cognitive] while turning to non-dominant and dominant side and performance of Step Test by non-dominant and dominant leg after 10 weeks of the Balance Wise intervention. There were no significant differences for all comparisons.
Table 7.9 Comparison of the performance of Timed Up and Go test [basic and cognitive] while turning to non-dominant and dominant side and performance of Step Test by non-dominant and dominant leg

<table>
<thead>
<tr>
<th>Non-dominant</th>
<th>Dominant</th>
<th>z</th>
<th>p</th>
<th>CI 95%</th>
<th>lower</th>
<th>upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG[B]</td>
<td>8.81</td>
<td>2.01</td>
<td>8.98</td>
<td>1.71</td>
<td>0.646</td>
<td>0.675</td>
</tr>
<tr>
<td>TUG[C]</td>
<td>13.11</td>
<td>6.18</td>
<td>15.04</td>
<td>8.66</td>
<td>-0.652</td>
<td>0.241</td>
</tr>
<tr>
<td>ST</td>
<td>26.40</td>
<td>7.65</td>
<td>27.10</td>
<td>7.59</td>
<td>-0.652</td>
<td>0.254</td>
</tr>
</tbody>
</table>

*Notes.* CI, confidence interval; TUG [B], Timed up and Go test basic; TUG [C], Timed Up and Go test cognitive; SD, standard deviation; ST, Step Test; z, Wilcoxon Signed Rank Test; significant difference, p < 0.05 (2-tailed)
7.8 Discussion

The specific objectives of this study were to evaluate the acceptability, practicality, adherence, viability of recruitment strategies, safety, and potential benefits of Balance Wise in older adults with self-reported memory loss. Figure 7.4 illustrates the synthesising of the findings showing the linkages between the qualitative and quantitative findings.

7.8.1 Acceptability and adherence

What do the current findings say about the feasibility of this complex exercise programme? The findings found that the exercise intervention was feasible to be conducted with older adults with self-reported memory loss in a group-based exercise programme.

The synthesising of the findings from qualitative and quantitative data found that the acceptability of the Balance Wise intervention was influenced by the perceived benefits of participating. Perceived benefits highly contribute to reasoning and decision making as described in fuzzy-trace theory (Reyna & Adam, 2003; Reyna & Brainerd, 1995). Within the fuzzy-trace theory, there were five components that related to this decision making: “1) stored knowledge and values; 2) mental representations of problems or situations; 3) retrieval of knowledge and values; 4) implementation of knowledge and values; and 5) developmental and individual differences in monitoring and inhibiting interference” (Reyna & Brainerd, 2011), p. 182). From the theory, we know that older adults with memory loss are able to retrieve old information, i.e., they can retrieve information from their long term memory. I hypothesise that these memories and knowledge of perceived benefit from exercise may have been accessed and informed the decision to participate in the study. The decision also could be related to awareness of vulnerability of the memory issue that deteriorates later in life, and plays an important role in health related, intervention decision making (Löckenhoff & Carstensen, 2004). Thus, this directly influenced their decision to participate in the Balance Wise intervention. In this current study, the participants also made a decision whether to participate in a group- or an individual-based Balance Wise.
Figure 7.4 The synthesising of the findings in qualitative and quantitative terms
The decision to conduct both group- and individual-based types of exercise was based upon the findings of the qualitative study described in Chapter 6. However, the findings of the current study indicate that group exercise appears more acceptable than the home-based. The reasons for this are: (1) the recognition of the value of the group setting in supporting both the person with memory loss and their support person, (2) it appeared to build intrinsic motivation, (3) the sense of belongingness derived from being part of a group, and (4) the communication from the instructors to ensure all members of the group could participate. These concepts are discussed below.

Support systems have been demonstrated in other studies to be highly beneficial for older adults with memory loss. A similar finding was found in Chapter 6 of this thesis. A ‘support model’, that emphasises what an older adult with memory loss can achieve, has been introduced to assist older adults with memory loss and their support person to adjust, navigate and access services, and enable the person to participate in regular activities of their life and actively engage in their communities (Goeman, King, & Koch, 2016). Providing continuity of meaningful activities has been found to be a key factor in person-centred care (Edvardsson et al., 2010; Goeman et al., 2016) to improve quality of life, health and well-being (Edvardsson, Petersson, Sjogren, Lindkvist, & Sandman, 2014; Phinney, Chaudhury, & O’connor, 2007), reduce depression (Brodaty, Green, & Koschera, 2003), and reduce the burden of the support person (Brodaty & Donkin, 2009). A group intervention led by well trained and knowledgeable instructors appears to be one method of supporting older adults and the people who support them to be engaged in fall prevention exercises. How older adults with memory loss can be supported to be more physically active and engage in exercises to prevent falling are important areas of future investigation.

The group environment was valued highly by those who lived alone due to the companionship they derived from it. The interviewees spoke of how they could exercise in a non-judgemental way irrespective of their problems. Developing positive relationships, without disrespect or discrimination due to the level of the disability and/or disadvantages that a person might have, is in keeping with the psychological theory of belongingness (Baumeister & Leary, 1995). In belongingness theory, older adults
tend to seek companionship with others rather than exist in isolation (Beauchamp, Carron, McCutcheon, & Harper, 2007). Studies have found that one of the predictors of adherence to a programme is the ongoing support from family members and the environment (Burke, Carron, Eys, Ntoumanis, & Estabrooks, 2006; Dishman & Buckworth, 1996). This social context is especially important when engaging in physical activity (Burke et al., 2006).

Participants, either in group- or individual-based Balance Wise, were complementary of the meaningful way the instructors communicated with participants. As the group included people with a mixed cognitive ability, DM and I purposefully used plain language and tried to avoid repetitions, elaborations, and additional instructions that would confuse the participants who had more moderate levels of cognitive impairment (Ripich, 1994; Savundranayagam, Ryan, Anas, & Orange, 2007; Small, Gutman, Makela, & Hillhouse, 2003; Small, Kemper, & Lyons, 1997). In the individual-based setting, more discussion could take place to adapt the exercises to the ability of the participant.

Throughout the intervention, the perceived benefits of the programme became stronger, which in turn strengthened the acceptability, and thus participant adherence to the intervention. The findings of this current study might suggest two categories of participants. The first category comprises participants who were able to comprehend the theory behind each of the exercises, thus they had autonomy to decide to attend and complete the whole 10 weeks of Balance Wise. In contrast, the second category, which comprised those participants with limitations in reasoning their decision to take part was solely determined by the support person. However, all participants in this category appeared at peace with the relinquishment of their own decision making. More discussion on adherence, particularly the reasons for dropping out takes place later in this chapter (see 7.9.3, pg. 277). Furthermore, acceptability became stronger when the participants started to become aware of the changes in their stability and thus recognised the need of such support systems to assist in their daily life. The perception of improvement in postural stability performance was affirmed by the results from postural stability measured by Step Test and TUG [basic] (see 7.9.5, pg. 280).
7.8.2 Practicality

The discussion on practicality mainly focuses on the practicality of the participant to instructor ratio and the practicality of the exercise prescription during the intervention.

The intervention was conducted by two instructors (DM and myself) and assisted by three support persons. This meant that there was a ratio of 1 “instructor”: 2 participating older adults with memory loss. Based on this highly supportive ratio, the exercise intervention was found to be practical and doable but is, potentially, with this level of support input, not sustainable long term. Thus, further research which explores whether an increase in the ratio of exercise participants to “instructors” impacts on the participants ability to exercise effectively and safely is called for. The next paragraph might explain these queries.

In this current study, the cognitive level of all participants who completed 10 weeks intervention was classified as normal to mild impairment. However, it was evident that two participants in particular found it difficult to do the exercises. They found it difficult to follow the instructions. It seems that, for those who have more limitation in cognitive function there needs to be a one-to-one instructor:participant ratio to ensure that the participant performs the exercise correctly to avoid harm and to maximise benefit. Previous research has found a positive effect on postural stability performance after one-to-one exercise training programme for an older adult with severe cognitive impairment (Mirolsky-Scala & Kraemer, 2009). In contrast, a group (average of 5 participants per group) exercise programme among older adults with severe cognitive impairment did not result in significant improvement (Rolland et al., 2007). Inconsistency of the findings might be influenced by the prescription of the exercises and the number of participants in each study. Further study is warranted.

The participants also suggested that the exercises should be repeated following the same sequences. It makes the exercises easy to remember and be retained in the memory. The literature supports this concept; older adults with cognitive impairment learn best under consistent practice conditions, constant practice of a specific and relevant task to their abilities (Dick, Hsieh, Dick-Muehlke, Davis, & Cotman, 2000;
Harrison, Son, Kim, & Whall, 2007; van Halteren-van Tilborg, Scherder, & Hulstijn, 2007). How the exercises can be learnt best is explained by the theory of motor relearning among older adults with cognitive impairment these adults use procedural memory and learning systems which are still intact (Harrison et al., 2007; van Halteren-van Tilborg et al., 2007).

The addition of a secondary cognitive task while balancing was challenging for participants. Undertaking dual tasks were found in Chapter 4 to improve postural stability in older adults with cognitive impairment (de Andrade et al., 2014; Manckoundia et al., 2006; Suttanon et al., 2012a). Dual tasks were associated with attentional demand and older adults with cognitive impairment were at high risk of falling because of the increment of cognitive load (Barra et al., 2006). Thus, dual task activity should remain in an exercise intervention that targets postural stability in older adults with cognitive impairment. The challenges might also be influenced by the difficulty and complexity of the dual tasks.

### 7.8.3 Adherence

Adherence to the intervention was good and varied from 60-100% among participants who were tested post intervention, with participants only “dropping out” due to health reasons and not due to the intervention itself. Three of the five participants who dropped out were diagnosed with dementia and the MMSE mean (SD) score was 21 (4) (range 16-27). Another two participants with MMSE scores of 26 and 27 dropped out without known reason. Previous studies conducted among older adults with cognitive impairment found adherence rates from 50%-80% to a 6 months exercise programme (Tak, Van Uffelen, Paw, van Mechelen, & Hopman-Rock, 2012; Suttanon et al., 2013a). The dropout rate in this current study was relatively high 33% in comparison to studies by Tak et al. (2012) and Suttanon et al. (2013) which reported 13% and 22%, respectively (Suttanon et al., 2013a; Tak et al., 2012). The reasons for lack of completion of the full programme were similar to the current study, namely ill-health (Suttanon et al., 2013a; Tak et al., 2012), although pain was a reason in the Tak et al. study (Tak et al., 2012).
7.8.4 Recruitment and sample characteristics

The recruitment process ratio of the current study was reported as per the Consolidated Standards for Reporting Trials (CONSORT) guidelines for phase III trials. The CONSORT statement suggests that the generalisability of the trial’s results and its potentially eligible participants’ assessment for eligibility were discussed, including the recruitment fraction as illustrated in Figure 7.2 (Wright et al., 2006).

The recruitment process for this project was challenging. The recruitment strategies used were: Alzheimer’s Society Otago newsletter and the Alzheimer’s Society Otago field officer’s home visits; local community-based dementia day care programmes; Age Concern (a non-government organisation that supports older adults) newsletters and communication channels; public noticeboards of local community centres (e.g. the public library, local supermarkets, churches), hospital and local GP clinics; and participants who had been in the previous studies of this thesis. However, this strategy yielded small numbers of volunteers.

This current study found that participation in previous studies by volunteers increased the number of participants in the study, as suggested by Caldwell et al. (2010) (Caldwell, Hamilton, Tan, & Craig, 2010). The previous volunteers were recruited from the local community-based dementia day care programmes and it was found to be a successful recruitment strategy (Shue, 2011). Caldwell et al. (2010) also suggested that attendance to an education session could increase the response rate (Caldwell et al., 2010). However this approach did not change the number of participants in our study, as we had presented the rationale and outline of the study in an Alzheimer’s Society Otago seminar. The small number of respondents through this channel might be because of the small number of attendants at the seminar. The reason may also be related to not recognising that cognitive limitations are influencing the decision making capacity of older adults with Alzheimer’s disease and thus their need for any intervention (Trachsel et al., 2015) as discussed in Chapter 6.

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As previously discussed in Chapter 5 and 6, I changed the terminology after consultation with Alzheimer’s Society Otago and local older adults rest home facilities, the term was changed from ‘Alzheimer’s disease’ to ‘self-reported memory loss’.

Further recruitment efforts via newspaper advertising, using this term, proved successful. Seventeen participants responded. However, only half of these agreed to complete the first assessment after they were informed about the purpose of the study, and this is for reasons unknown. In future it would be good to explore why older adults with memory loss do not want to participate in research of this kind.

In a study targeting frail older adults aged 75 years and above by Gill et al. (2001) (Gill, McGloin, Gahbauer, Shepard, & Bianco, 2001), these researchers employed two recruitment strategies: via 1) primary care physicians, and 2) patient rosters of primary care physicians, and this proved successful. However, this recruitment strategy is often onerous for primary care physicians and clinics and they frequently request funding to resource this form of recruitment. I did not have such funding available. Also, such a recruitment strategy requires that the researcher build strong relationships with the primary care physicians. Future studies would need time to develop such relationships and the necessary funding to use this form of recruitment strategy. In addition to that, at the time of my study there was no “Dementia or Memory Clinic” run by the local district health board which would have enabled me to potentially recruit more eligible participants. At present, older adults experiencing cognitive decline are managed by their primary physician in the community only. Each physician appears to use a different outcome measure, if they use any at all, to diagnose dementia or Alzheimer’s disease. Use of a standard core set of diagnostic tools, clinically and in research, would enable recruitment of a homogenous group of participants.

Dementia research recommends the recruitment of a diverse population, especially older adults with dementia, requiring both a socio-cultural perspective and a constructivist approach (Dilworth-Anderson, Thaker, & Burke, 2005). A socioculture approach “suggests that human beings are not limited to their biologic inheritance, as other species are, but are born into an environment that is shaped by the activities of
previous generations and that higher order functions develop out of social interaction” ((Dilworth-Anderson et al., 2005) p. 256)). Whereas a “constructivist approach suggests that the human experience emphasises meaningful action by developing the self in complex and unfolding relationships, which take place within a cultural and social context” ((Dilworth-Anderson et al., 2005) p. 256). The development of cultural and social understanding could lead the researcher to better understanding of the common attributes, for instance, belief, attitudes, communication pattern and values within the cultural groups. Thus, trust between potential participants and the researcher could develop that might help in recruitment (Nápoles-Springer et al., 2000).

### 7.8.5 Possible benefits of the programme

Although this current study was a proof of concept study, postural stability and falls risk outcomes were measured to obtain a sense of the benefits of the intervention on these constructs, given that the intervention was designed to improve postural stability and thereby reduce falls risk. At the baseline, three variables were found to have significant differences between the group- (n = 12) and the individual- (n = 3) based Balance Wise. These were: 1) TUG [cognitive] while turning to dominant leg; 2) Step Test performed by non-dominant leg; and 3) Step Test performed by dominant leg. At 10 weeks post intervention, the only significant improvements found were for the TUG [basic] and Step Test on the dominant leg. Even though falls risk measured by the PPA did not reach significant difference, participants did derive benefits from it based on individual performance. Improved performance of both the TUG tests [basic and cognitive] and Step Test based on dominant and non-dominant leg were found. None of the comparisons, between turning to non-dominant and dominant leg while performing TUG test [basic and cognitive] and Step Test performed by dominant and non-dominant leg, reached significant differences.

Despite the small unequal numbers of participants in both groups, there was a significant difference at baseline for TUG [cognitive] and Step Test between them (group- and individual-based Balance Wise). The level of severity of cognitive function could be another reason. The individual-based Balance Wise mean (SD) score MMSE was 21 (5) compared to the group-based Balance Wise mean (SD) of 25 (4). In future
trials, the distribution of the data should be equal and not significantly different (Assmann, Pocock, Enos, & Kasten, 2000).

The findings of a significant difference only showed while performing TUG test [basic] but not TUG test [cognitive]. This might be related to the challenge of the task, as it is more complex than the TUG test [basic]. However, this cognitive TUG mimics everyday tasks and thus the participants learn better. As discussed in Chapter 4, dual tasking was one of the associate factors for postural instability among older adults with cognitive impairment. Thus, in this current study, I incorporated dual tasking activity, i.e., walking while holding cup full of water, in the 10 weeks regime of Balance Wise. This study is consistent with a previous study evaluating the effects of cognitive motor dual tasking intervention among 20 older adults with mild cognitive impairment (MoCa < 26) who live in long term care (Delbroek, Vermeulen, & Spildooreen, 2017). After 6 weeks of a virtual reality intervention, participants showed improvement in time take to complete the TUG test [basic] but still had difficulty completing TUG test [cognitive] (Delbroek et al., 2017).

The construction of the Balance Wise intervention was adapted from the Otago Exercise Programme, which was primarily designed to improve balance and reduce falls. Both the Suttanon et al. (2013) study and this current study suggest that an exercise intervention that includes strength, balance and a walking course may improve mobility performance and postural stability in older adults with cognitive impairment (Suttanon et al., 2013a). In additional, this current study suggests that dual tasking activity should be incorporated into the exercise programme due to that fact that the executive function of older adults with cognitive impairment is affected. It could be argued that as the exercise intervention was only done once a week for 30 minutes over 10 weeks that it may not have been sufficient to meet the recommendation of the duration of the exercises to gain changes in falls risk and postural stability, especially during dual tasking (Avin et al., 2015; R. Kenny et al., 2011). However, this regimen was based on (1) what older adults interviewed in the qualitative study requested (Chapter 6), (2) keeping the duration short due to concentration levels of older adults with cognitive decline (Chapter 6), and (3) the success of the SAYGo classes in which
the intervention programme was held once a week for 10 weeks (Chapter 2) (Waters et al., 2011). Thus, larger trials are required to investigate the strategies to ensure an adequate regimen of exercise is further explored.

7.9 Implications and recommendations

This current study provides preliminary data and knowledge of the feasibility of Balance Wise. The implications and recommendations of the findings of this study are discussed in Chapter 8, Discussion, p 285.

7.10 Strengths and limitations

The main strength of this study was that it followed the guidelines of complex intervention (Campbell et al., 2000; Campbell et al., 2007; Craig et al., 2008). The three preliminary studies strengthen the Balance Wise intervention in terms of the associate factors of postural stability that impact older adults with cognitive impairment (Chapter 4), the outcome measures to be used (Chapter 5), and the construction of Balance Wise intervention based on Chapter 6. The construction of Balance Wise was largely based on the evidence based Otago Exercise Programme (Campbell & Robertson, 2010; Campbell et al., 1997; Thomas et al., 2010; Waters et al., 2011) and which was then modified based on the findings of the studies in this thesis and on reviewed literature.

This study had few limitations, namely: 1) the number of participant recruited; 2) the bias of the interviewer; and 3) the cognitive function of the participants after 10 weeks intervention.

The first limitation was that only one participant undertook the individual-based exercise, thus limiting comparison of the data with the group-based intervention (both based on qualitative and quantitative data). Another issue related with the small number of participants recruited was that this reduced the value of the statistical analysis of the quantitative data. It could be argued that completing the statistical analysis was not really worthwhile given the small numbers. It was not known why older adults with memory loss did not want to participate in this study. Thus, this is the most important area to be explored in the future before a feasibility study can be done.
The second limitation was that the interviewer was the same person as the instructor who conducted the intervention. This could impact on the information received from participants. Throughout the programme, the interviewer built up a connection with the participants, thus was the study was exposed to reporting bias. It would be worthwhile in the future, for the person conducting the interviews to not be the person undertaking the assessments or instructing the intervention. This would reduce bias.

This current study did not measure the changes in the cognitive function after the participants completed 10 weeks of intervention. I acknowledge this as limitation of the current study.

7.11 Summary

This study suggests that Balance Wise is feasible and has potential benefits to improve postural stability among older adults with self-reported memory loss. There are a few suggestions for improvement: 1) the intervention should be conducted based on the functional ability of the participant; 2) there should be more activities related to eye-hand / eye-leg reaction; 3) and more activities with dual tasking; and 4) strengthening the support system is important. There are two support systems needed: 1) for older adults with cognitive impairment; and 2) for the support person. The next study needs to test further the Balance Wise intervention based on the suggestions made by the participants.

The next chapter, Chapter 8, provides a final data synthesis and critique and these lead to an overview of the thesis and a final discussion of the important findings of all the studies encompassed in this thesis.
CHAPTER 8

Discussion

8.1 Introduction

Chapter 8 is the last chapter of this thesis. It contains the final data synthesising and critique, leading to an overview of the thesis and addresses the important findings of all the studies encompassed in this thesis. I also discuss these findings in relation to implications for practice and directions for future study. Finally, I present a summarised conclusion for the thesis.

8.2 Overview of this thesis

In this chapter I have integrated all the findings and discuss the most relevant issues in addressing the thesis aim: to develop, and evaluate the feasibility of, an exercise-based intervention to improve postural stability and reduce the risk of falls in older adults with mild to moderate cognitive impairment due to Alzheimer’s disease. Four studies were conducted to address this aim. The first (1) study was a systematic review to answer two research questions: Do older adults with mild to moderate Alzheimer’s disease have reduced postural stability compared with a control group of their healthy peers?, and: What factors contribute to, or impact on, postural instability in people with mild to moderate Alzheimer’s disease? The second (2) study evaluated psychometric properties of the PPA and the TUG test for the measurement of postural stability and falls risk. This was done to identify appropriate, clinically-based outcome measures to use to evaluate the intervention. The third (3) study explored opinions of older adults with self-reported memory loss and their primary support person as to the optimal way to deliver an exercise programme. The fourth (4) study explored the feasibility of the intervention (subsequently named the Balance Wise intervention) for older adults with self-reported memory loss, to improve postural stability and reduce falls risk, delivered either as a home-based individual programme or as a community-based group programme. Each study has been reported in full, one chapter per study, in Chapters 4
to 7. In this chapter I discuss specific important points which emerged, that I think require further highlighting. These points are: 1) Denial and level of acceptance; 2) Support system (divided into two sections: (i) support decision making and (ii) support derived from the group-based Balance Wise; 3) Complexity of the activity; and 4) Practicality of the intervention. The implications and recommendations are discussed together.

8.2.1 Denial and level of acceptance

In the early development of this thesis, I wished to focus on older adults with mild to moderate Alzheimer’s disease. For this reason my systematic review, as the first phase of developing this complex intervention, targeted this population group. In the subsequent studies when I wished to recruit older adults with mild to moderate cognitive impairment due to Alzheimer’s disease, I ran into difficulties. Indeed, this aspect remained a challenge for all the studies of this thesis, despite instigating a number of strategies to improve recruitment. I specifically wished to target people with mild to moderate cognitive impairment because of the facts that, this population has adequate levels of cognitive and physical function to be able to participate safely and effectively in exercise classes and thus, potentially, could benefit from exercise-based falls prevention interventions (Steinberg et al., 2009; Suttanon et al., 2011; Suttanon et al., 2012a). Ironically, this population, rather than those with severe cognitive decline, is likely to receive the greatest benefits from an exercise intervention (Heyn et al. 2004; Wesson et al., 2013). However, in reality, I found it very difficult to reach older adults who have been diagnosed with Alzheimer’s disease, when symptoms were relatively mild. After discussion with the Alzheimer’s Society Otago, and the manager of a long term care facility, I decided to change the term from “Alzheimer’s disease” to “self-reported memory loss”. By widening my recruitment criteria to older adults with self-reported memory loss, I had better success, but there appeared to be a stigma relating to deteriorating cognition and the potential participant either did not have, or did not want a diagnosis. Further, any who had confirmed diagnosis appeared to be withdrawing from community participation. If older adults with deteriorating cognitive function, and thus become “classified” as having “mild or moderate” cognitive impairment, either are not ready to accept their diagnosis, or are not sure whether their
acknowledged symptoms are “normal ageing” or not, then this will be an extremely challenging population group to recruit from for studies. Further to this, if a person did seek medical advice, they were managed by their general practitioner (GP) (and GPs appeared, individually, to use different systems to make a diagnosis of Alzheimer’s disease) as there was, at the time of my research, no dementia care pathway or Dementia / Memory Clinic locally.

The recruitment difficulties are best demonstrated via the qualitative findings of Chapter 6. These results described the cyclic process of older adults with cognitive impairment: 1) awareness; 2) denial; 3) acceptance; and 4) coping strategies. Denial and acceptance are two complex psychologically-based reactions. Participants appeared to fluctuate back and forth between these two, influenced by their changing awareness and progressing symptoms over time, while having to continually adjust to new limitations in life (Kralik, 2002; Paterson, 2001). There was no uniformity in this as they have to deny or accept every limitation as it presents whilst living with cognitive impairment. Simply put, one day they might accept the disease but, on another day, they might not. It was evident this cyclic process influences their decision making and this included whether or not to take part in my study. I postulated that the reason the reason I was having this challenge may be related to older adults’ awareness of having a cognitive problem and their level of denial-acceptance of this problem. It was evident that, those who were at the stage of acceptance of the deterioration of their cognitive impairment were more willing to participate in the intervention. In contrast, those who were still at the stage of denial, would not participate even though they reported that they might be interested in an individual home-based intervention. The finding of this cyclic process is similar to what Cohen et al. (1984) described in his paper as a conceptualisation of six psychological reactions in persons with cognitively impairment: 1) “pre-diagnosis-recognition and concern”; 2) “during diagnosis-denial”; 3) “post-diagnosis-anger, guilt, and sadness”; 4) “coping”; 5) “maturation”; and 6) “separation” (Cohen, Kennedy, & Eisdorfer (1984), p.11). These six psychological reactions were derived from clinical interviews with a large cohort of people with Alzheimer’s disease (Cohen et al., 1984).
I was attempting to recruit older adults with early Alzheimer’s disease and it might be that the individuals I was targeting were somewhere between the stages of recognition and concern (Cohen et al., 1984), stages which are highly associated with stigmatisation. Stigmatisation can be self-stigma (by a person with Alzheimer’s disease) or stigma from others in society towards people with Alzheimer’s disease (i.e., health care professionals, members of the public, etc.) (Blay & Peluso, 2010; Garand et al., 2009; Liu, Hinton, Tran, Hinton, & Barker, 2008; Werner & Heinik, 2008). A consensus statement from the World Health Organisation and World Psychiatric Associations agreed that stigmatisation is not acceptable (Graham et al., 2003). In this instance, I highlight self-stigma by the older adults with Alzheimer’s disease. People often self-stigmatise because of the mistaken belief there is an association between deteriorating memory and negative psychological attributes such as being weak, irresponsible or irrelevant (Graham et al., 2003; Liu et al., 2008) leading to their belief they will be treated differently in the community (Crisp et al., 2000; Werner & Heinik, 2008). Crisp et al. (2000) surveyed 1737 individuals with various conditions of dementia and found that stigmatisation is related to the internal beliefs that older adults with cognitive impairment have. In other words, they perceive that they will be treated differently if the community knew that they were diagnosed with a condition called dementia (Crisp et al., 2000). As another example, in a study by Werner and Heinik (2008), the researchers explored the relationship of stigma and older adults with Alzheimer’s disease and found that 61% of these older adults limited their participation within the community and reduced their social contact after receiving a diagnosis of Alzheimer’s disease (Werner & Heinik, 2008).

There was also a relationship between denial of the disease and the level of depression among older adults with Alzheimer’s disease (Cotrell & Schulz, 1993; Feher, Mahurin, Inbody, & Crook, 1991; Reisberg, Gordon, McCarthy, & Ferris, 1985; Starkstein et al., 1997; Starkstein et al., 1996). Cotrell and Schulz (1993) reviewed the cause of the depression and suggested that it is one of the consequences of decline in everyday functional status, i.e., it was a natural consequence of the disease process (Cotrell & Schulz, 1993; Pearson, Teri, Reifler, & Raskind, 1989). Depression may be also due to experiencing a loss of status, interdependence and autonomy, as the person’s cognitive
function deteriorates (Cotrell & Schulz, 1993). For example, Williams et al. (1988) investigated sleep as a biological marker for early-stage Alzheimer's disease and used similar methods of recruitment to mine (newspaper, radio announcement, a talk to senior groups, distribution of flyers to retirement residences and clinics) (Williams, Vitiello, Ries, Bokan, & Prinz, 1988). The results showed that the group of older adults with mild cognitive impairment and depression associated with Alzheimer’s disease was the most difficult population to recruit (Williams et al., 1988).

As I report in Chapter 7, two participants with the diagnosis of dementia were unable to complete the 10 weeks of the intervention and were reported to have declining health. This finding is consistent with previous studies exploring the attitudes towards exercises and found that progression of the disease is a barrier to their participating in research (Cedervall & Åberg, 2010; Chong et al., 2014; Malthouse & Fox, 2014; Suttanon et al., 2012; Suttanon et al., 2012a). One of these studies explored the barriers to engaging in exercise after participants had been in a structured exercise programme (Gras et al., 2015) and three studies explored the attitudes of participants towards physical activity (Cedervall & Åberg, 2010; Chong et al., 2014; Malthouse & Fox, 2014). However, the main limitations of these studies were that: they recruited small numbers of participants: n = 5 (Malthouse & Fox, 2014); n = 2, (Cedervall & Åberg, 2010); the interviews were carried out with those who already participated in the exercise programme (Gras et al., 2015); they used focus groups with a homogenous population (i.e., ranging from normal cognition to older adults with Alzheimer’s disease) (Chong et al., 2014) and; all the studies settled for reporting descriptively with no in-depth analysis (Cedervall & Åberg, 2010; Chong et al., 2014; Gras et al., 2015; Malthouse & Fox, 2014). It might be true that older adults with Alzheimer’s disease have declining health and that this was their primary reason for not exercising. However, the reasons for the low recruitment number in my study are still not clear.

8.2.2 Support system

Support decision making

It was evident from comments made in Chapters 5 and 7 that some of the decisions regarding participation in my study were made by support people. The primary reason
for support people deciding for the person they support that they should participate was the belief it might be beneficial for them. The existing literature also suggests that older adults who have limited cognitive function require a support person as a surrogate for translating their needs. However, these decisions may not always represent what the person with dementia wishes and thus may not represent truly person-centred care. It must be recognised that people with dementia have a voice and that their autonomy needs to be protected when a decision closely involving them needs to be made. Allowing the support person to make these decisions unilaterally is contradictory to person-centred care for older adults with Alzheimer’s disease, whose autonomy, as a person with a limitation in cognition, should be respected (Gauthier et al., 2013; Strech et al., 2013). How to truly action this is an issue that needs attention and further research (Cohen-Mansfield, 2000; Karlawish, 2000).

Support derived from the group-based Balance Wise

Another finding from Chapters 6 and 7 was the importance of the ‘support system’ for older adults with cognitive impairment. A support system is clearly required for such a person to successfully participate in an intervention for a long term. Whilst this may be in the form of a support person, from my study findings support can come also from a group activity, such as Balance Wise. The group Balance Wise programme provided a social connectedness that was built up during the course of the intervention. This connectedness was not only for the person with cognitive impairment but also for the support person. This was evident in the interviews reported in Chapter 6, for example, with quotes such as “taking care of a person (with) [who is] cognitively impaired require[s] a huge amount of energy”. The study reported in Chapter 7 found that support people created relationships with other support people outside of the intervention. Support people appear to be in need of moral support as well as practical help with such aspects of life as household tasks, finances, psychological pressures or stresses, and the resources available to help with taking responsibility for the care of someone with Alzheimer’s disease (Clipp & George, 1990). Yet the responsibilities and demands on the support person are changing in nature as time goes on, and this has implications for their psychological and physical wellbeing (Fredman, Daly, & Lazur, 1995; Schulz & Beach, 1999; Wilks & Croom, 2008). The literature suggests that there
is an impact on psychological and physical well-being of support person especially when the support person is the loved one (Belle et al., 2006). For an example, Clipp and George (1990) evaluated the support person’s needs and the pattern of social support among 510 families who were central to the care of an older adult with cognitive impairment (Clipp & George, 1990). The study found three important needs: 1) network contribution from other family members and nearest friends; 2) physical and mental health support; and 3) social support of support person (Clipp & George, 1990). The study also found that the support person facing the greatest burden were those who have themselves ill health (including stress) (Clipp & George, 1990).

Furthermore, Wilks and Croom (2008) evaluated the protective factors against stress among 229 support persons (mean age 49 years) of older adults with Alzheimer’s disease. The researchers looked at the possibility of social support as a protective factor (Wilks & Croom, 2008). They used three conceptual model variables: 1) perceived stress measured by Perceived Stress Scale (PSS); 2) social support measured by Perceived Social Support Scale (S-PSSS); and 3) resilience measured by the Resilience Scale (S-RS) (Wilks & Croom, 2008). The study found that the most influential to self-perceived resilience were family, friends and social support (Wilks & Croom, 2008). Thus these results might explain the impact of friends and social support on the psychological health of the support person that I also found and described in Chapter 7. Thus, it could be that going out for an activity, such as Balance Wise, helps to alleviate stress and provides support through socialising with peers who are experiencing similar circumstances.

8.2.3 Complexity of activity for older adults with mild cognitive impairment

At present, there are limited interventions specifically targeting postural stability in older adults with Alzheimer’s disease. Previous studies present limited robust evidence as to whether an intervention targeting postural stability reduces the risk of falling in this population (Chapter 2). The reasons for this are not clear. Thus, I thought it would be valuable to start the development of such as intervention by first investigating previous studies to identify which component of postural stability appeared to be most affected in this cohort. In my first study, the systematic review set out in Chapter 4, I
found strong evidence that older adults with Alzheimer’s disease have reduced postural stability in both the static and functional components (Mesbah et al., 2017). This finding was supported by the comparative analysis between older adults with cognitive impairment and the normative values I sourced in my study and reported in Chapter 5. In addition, my systematic review found that activities, that required attentional demand and vision in particular, were associated with falling in this population group. Thus my developed intervention, Balance Wise, whose aim was to improve postural stability and reduce the risk of falling in older adults with self-reported memory loss, particularly focussed on these components (Mesbah et al., 2017).

I explored whether older adults with cognitive impairment were aware of changes in their postural stability in the study reported in Chapter 6. It was evident that many older adults with cognitive impairment lacked awareness of their functional abilities and difficulties and this is in agreement with other research (Amanzio et al., 2013; Debettignies, Mahurin, & Pirozzolo, 1990; Martyr & Clare, 2018; Ott et al., 1996). For example, in the Chapter 6 study participants reported tripping while walking on uneven terrain or uneven surfaces. They also talked about slow reaction times when responding to unexpected perturbations. It may be that older adults with cognitive impairment see these functional difficulties as normal for an aged person. Conversely, the support person, who was often the first person to recognise changes in functional ability, suspected that these falls were not “normal” and that they might reflect the progression of the disease. Previous research suggests that the support person is highly accurate in identifying difficulties whereas older adults with cognitive impairment are more likely to underestimate difficulties (Reifler, Cox, & Hanley, 1981). The functional limitations became more obvious, especially when it came to executing complex activities such as stepping up a staircase (Chapter 5). In Chapter 6, I hypothesised that there is perhaps some ‘denial’ which was part of the participants’ coping strategies.

While the ‘denial’ may have been a coping strategy, its presence created additional risk. For example, walking on uneven terrain, without appropriate risk awareness or overinflated judgement of self-ability, might expose them to additional risk and they are then unable to expect, or correct, a stumble, trip or fall (Coppin et al., 2006; Patla,
1997; Patla & Shumway-Cook, 1999). Thus, it is not only a requirement to evaluate and address the postural stability of this cohort but also to explore the associated factors underlying this difficulty, which is related to poor executive function (de Andrade et al., 2013; Liu-Ambrose et al., 2008; Martyr & Clare, 2018; McCabe et al., 2010; Muir, Speechley, et al., 2012; Schwenk et al., 2010; Silsupadol et al., 2009; Tappen & Hain, 2013). Based on the findings reported in Chapters 4-6 and previous literature, I designed Balance Wise, to include dual task activities and found that these activities were the most challenging for participants to complete (see Chapter 7). The execution of a dual task requires the participant to think and perform an activity together and this requires the use of executive function which is important for the planning and execution of movement (Rapp et al., 2006). Participants in the study reported in Chapter 7, who had the most disturbances of executive function (as measured by the MMSE), were those who had most difficulty performing dual task activities. This thesis suggests that older adults with self-reported memory loss should be trained with a lot more dual task activities. Therefore, future research needs to not only continue to investigate interventions that address postural stability, but also interventions to maximise or improve the executive function of older adults with cognitive impairment.

As mentioned earlier in Chapter 7, the TUG [basic] test comprised four components of functional ability. A previous study found that older adults, who were at risk of falls, require many steps to complete the turning (Dite & Temple, 2002). Although I did not find a significant difference between time to turn to the dominant and non-dominant side with this test in the study reported in Chapter 7, I did find this in the study related in Chapter 5. More specifically, I found differences between turning to the right and to the left side and time differences in this population. Furthermore, in Chapter 6’s study, older adults with cognitive impairment reported having problems while turning. It might be that turning is more affected than any of the other movement, thus it is the primary movement causing the increase in time to complete the TUG test. The differences, when the findings from the two studies in Chapter 5 and 7 were compared, might be explained by the participants who were included in these respective studies. In Chapter 7 participants were older adults with self-reported memory loss without a definite diagnosis [MMSE score mean (SD) = 24 (4), (range = 17-30)], whereas the
majority of participants in Chapter 5 had a diagnosis of dementia [MMSE score mean (SD) 19 (9), (range 14 – 28)]. This suggests that older adults who are more cognitively impaired may take longer time to complete this test. Some researchers have suggested that the relationship between falls and the different components of this test be evaluated separately, in particular the turn. This is because turning involves multiple changes and complex motor planning and execution (Dite & Temple, 2002). There is insufficient research on turning and its relationship to falls amongst older adults with cognitive impairment. Thus this relationship requires further research.

8.2.4 Practicality of the intervention

Safely and effectively delivering a group exercise intervention to older adults with cognitive impairment is not easy and comes with specific practical difficulties. In the class DM and I tried to use simple words and demonstrations to deliver the exercise instructions. Even so, frequently we found participants did not execute the exercise correctly, thus losing the potential effectiveness of the exercise, especially the strengthening exercises. I recommend that one-to-one sessions with older adults with moderate cognitive limitation will help them to appreciate the movement and thus better execute it. I offered participants a choice of group versus individual exercise, and only three participants wished for the individualised version. Only one participant was able to complete the intervention without difficulties, whereas the other two discontinued the programme due to deteriorating health.

I also anticipated the difficulties the two older adults with moderate cognitive impairment (MMSE score mean of 17 and 21), with a diagnosis of Alzheimer’s disease, who participated in the group-based Balance Wise, would have. During the exercise class, one support person and one instructor stood beside these individuals to help them with the activities for most of the classes. Thus the question arises, what is the practicality and the cost-effectiveness of this intervention (either one-to-one or group intervention) for creating a sustainable long-term exercise programme? As discussed in Chapter 3, it is normal for cost effectiveness of a complex intervention to be evaluated in the second phase (evaluation phase); after the effectiveness of the intervention has been evaluated. One previous study has presented cost effectiveness data for the home-
based Otago Exercise Programme in New Zealand (Robertson et al., 2001). Results showed that, in the intervention group, the cost for hospitalisation caused by falls was substantially lower compared to the cost of treatment for falls among older adults who were hospitalised ($n = 121$) in adults aged 75 years and older (Robertson et al., 2001). The costs were calculated based on two factors: costs for exercise programme; and costs of health care use due to falls. Thus, the study by Robertson et al. (2001) suggests that, when the number of falls reduces, the cost for treatment reduces. However, the cognitive status of the cohort of participants in this study was not stated.

I propose that a study similar to Robertson et al. (2001) should be conducted for Balance Wise in older adults with Alzheimer’s disease. It may be that individualised exercise is more effective for reducing falls risk than group delivery as the exercises are performed better and more safely. However, it is a potentially more expensive model of delivery and most likely prejudged to be not sustainable due to the ratio of staff required to support participants. Further the individualised programme loses the above mentioned benefits of the group programme. Thus a comparison study of both individual- and group- based intervention is required.

### 8.3 Recommendations for future research

This thesis was guided by the first development phase of a complex intervention. This phase is to identify problems and issues in the developed intervention as well as in the research methods employed to evaluate it. The integration of the findings of the studies of this thesis was useful to inform whether the intervention and the research of it are ready for the next development phase, i.e., evaluating the intervention in a feasibility randomised controlled trial. A key issue identified by this thesis was the challenge with recruitment, as previously described. Further research is required to optimise recruitment strategies, which includes how to identify and diagnose people with early Alzheimer’s disease / early cognitive decline and then attract them to participate in research, without causing loss of respect and autonomy.

Conducting a study involving older adults with cognitive impairment is complex and difficulties are frequently reported (Cohen-Mansfield, 2000; Karlawish, 2000). Two
key questions are, “What would be the best way to recruit participants with Alzheimer’s disease? What would be the best terms/language to use to prevent unintentionally triggering stigmatisation of this vulnerable population?” Previous studies found that to recruit older adults with Alzheimer’s disease, researchers needed to build strong relationships with the population (Shatenstein, Kergoat, & Reid, 2008; Chong et al., 2014), establish new partnerships with the community and local organisations (Chong et al., 2014; J. S. Smith, Morgan, & Smith, 2016), and ensure referral from a memory clinic (Grill & Karlawish, 2010; Smith et al., 2016). One of the best way to address stigmatisation is through working in partnership with advocates from non-government organisations, government agencies, associations, families and the public, and increase their literacy about the promotion of good mental health (Graham et al., 2003). There is, however, also reported in the literature, a relationship between depression, stigmatisation and withdrawal from community among people with Alzheimer’s disease. The issue of shared decision making and autotomy with regard to consent to participate in research trials, as discussed previously, also needs further exploration. Therefore, much work remains to be done to address the most effective way to recruit this population into research.

As I have stated above, not only does future research need to address how to attract people with early cognitive decline into studies, an early firm diagnosis is required. This is difficult in the absence of a Dementia or Memory Clinic. It also requires the person suspecting that they have a problem with cognition to seek help from their GP. This is again an area for further research.

To progress the intervention, further research areas identified, were: 1) interventions to improve executive function; 2) exploring the task of turning and its association with the risk of falls; and 3) comparison study between individual- and group-based exercises, especially the cost-effectiveness of these intervention types.

8.4 Thesis summary and conclusion

This thesis contributed new knowledge, both quantitatively and qualitatively, to the understanding of postural stability of older adults with mild to moderate cognitive
impairment. Based on this new knowledge, this thesis then developed, and undertook a preliminary evaluation of, an exercise intervention to address postural instability and, more importantly, reduce falls risk for this vulnerable population.

This current chapter highlighted four important issues that were evaluated as part of a complex intervention to improve postural stability and reduce fall risk among older adults with cognitive impairment: 1) The uncertainty of stage between denial and level of acceptance that impacted participation in the study; 2) Support system 3) The requirement for, but the complexity of, dual task activities; and 4) Practicality of the intervention in the sense of cost effectiveness of an individual- versus a group-based exercise programme. All these five important issues influenced participation and adherence of participants (older adults with mild to moderate cognitive impairment) in the intervention and this, in turn, impacts the sustainability of the intervention. However, in going forward it is clear the issues around recruitment need to be first addressed before further development and evaluation of the intervention can be progressed.

Given a small of numbers of participants, the results of the psychometric study (Chapter 5) could be argued and questioned. However, I identified the need for more evaluation of the turning component of the TUG test, and comparison of the side of turned to and leg dominance and their association with falls risk. As in Chapter 4, I found strong evidence that dual tasking and vision were factors associated with postural instability, thus the TUG test [cognitive] and the PPA might potentially provide valuable information. But these outcome measures need further study. Only then can an evaluation of fall risks and postural stability be reliably and validly assessed in my target population.

This thesis found strong evidence that older adults with mild to moderate cognitive impairment due to Alzheimer’s disease have reduced postural stability compared with their healthy peers (as described in Chapter 4) and this appears to be the first study to systematically provide evidence for this finding. The systematic review also suggested the areas that an intervention should be focused on to improve postural stability,
namely, dual task activities, activities that challenge visual input, and activities that challenge functional stability.

I found evidence that my intervention, Balance Wise, provides benefits not only for my targeted population but also for the people who support them. As both groups benefited, it is postulated that the group-based Balance Wise intervention within a community setting might be more beneficial in reducing stress and promoting well-being than the individualised home-based Balance Wise.

It was evident that older adults with cognitive impairment have reduced postural stability (Chapter 4). However, at present, it is unclear what components of postural stability need targeting and there is insufficient evidence of the benefits of current interventions to provide guidelines as to how to improve postural stability and reduce fall risk in this population. The Balance Wise intervention was found to be acceptable and has potential to improve postural stability among older adults with cognitive impairment. Further research however is required to develop it and evidence it further.
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Appendices
Appendix A: Ethical approval and Māori consultation

Ethical Approval: Conditional approval Chapter 5 and 6

Dear Assoc. Prof. Hale,

I am writing to let you know that, at its recent meeting, the Ethics Committee considered your proposal entitled “Postural stability in older adults with Alzheimer’s Disease”.

As a result of that consideration, the current status of your proposal is: Conditional Approval.

For your future reference, the Ethics Committee’s reference code for this project is: H14/035.

The comments and views expressed by the Ethics Committee concerning your proposal are as follows:

Please address the following comments before proceeding with the research:

The Committee questioned whether the sample size chosen (30) would be sufficient to gain meaningful results given the ideal sample size for such a study is 100, as noted in Section 2.1 of the application form. The Committee requests a further justification for the chosen sample size and also asks whether the possibility of collaboration in another locality has been considered.

The Committee asks for clarification on whether the study is only including competent participants who will be able to provide informed consent as noted in section 13.1, p 11 of the application form. The Committee suggested the additional inclusion of participants diagnosed with dementia and as such reflect this in the Information Sheet.

The Committee requests the following changes to the Information Sheet; i) Please write Associate Professor in full; ii) Under the project aims, point 1, second line, delete the word ‘for’
Before approval of the research to proceed can be granted, a response must be received addressing the issues raised above. The Committee expects that these comments will be addressed before recruitment of participants begins. Please note that the Committee is always willing to enter into dialogue with applicants over the points made. There may be information that has not been made available to the Committee, or aspects of the research may not have been fully understood. Please provide the Committee with copies of the updated documents, if changes have been necessary.

Yours sincerely,

[Signature]

Mr Gary Witte
Manager, Academic Committees
Tel: 479 8258
Email: gary.witte@otago.ac.nz

c.c. Professor G D Baxter  Dean  School of Physiotherapy
Dear Assoc. Prof. Hale,

I am again writing to you concerning your proposal entitled "Postural stability in older adults with Alzheimer’s Disease", Ethics Committee reference number H14/035.

Thank you for your letter of 31st March 2014 addressing the issues raised by the Committee.

The Committee appreciate the detailed justification given for the chosen sample size noting that the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) checklist used; the consultation undertaken with the local Alzheimer’s Society and the use of the specialist equipment required for the study not being widely available and therefore not feasible to conduct outside of Auckland.

The Committee is grateful for the clarification given in respect of why individuals with dementia will not be included in the study.

Thank you for the amendments made to the Information Sheet and the inclusion of evidence of Mario consultation for our records.

On the basis of this response, I am pleased to confirm that the proposal now has full ethical approval to proceed.

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.
Yours sincerely,

[Signature]

Mr Gary Witte  
**Manager, Academic Committees**  
Tel: 479 8256  
Email: gary.witte@otago.ac.nz

...
Dear Assoc. Prof. Hale,

I am again writing to you concerning your proposal entitled “Postural stability in older adults with Alzheimer’s Disease”, Ethics Committee reference number H14/035.

Thank you for the additional information received on 7th November 2014 in relation to the issues raised by the Committee regarding your recent request to amend the above study.

On the basis of this response the Committee accept and approve the amendments requested.

Your proposal continues to be fully approved by the Human Ethics Committee. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing. I hope all goes well for you with your upcoming research.

Yours sincerely,

Mr Gary Witte
Manager, Academic Committees
Tel: 479 6266
Email: gary.witte@otago.ac.nz

c.c. Professor G D Baxter  Dean  School of Physiotherapy
Dear Professor Hale,

I am writing to let you know that, at its recent meeting, the Ethics Committee considered your proposal entitled “Postural stability in older adults with memory loss”.

As a result of that consideration, the current status of your proposal is: Approved

For your future reference, the Ethics Committee’s reference code for this project is: H15/073.

The comments and views expressed by the Ethics Committee concerning your proposal are as follows:

While approving the application, the Committee would be grateful if you would respond to the following:

Sample size: The Committee noted that the sample size differed in the Protocol (page 3) and the application, question 4.2. Please could you clarify the number of participants.

Information Sheet: The Committee was of the view that the Information Sheet was lengthy and recognises that you might need to read it to participants. As such, the Committee asks for reassurance that this will be done if necessary.

Please provide the Committee with copies of the updated documents, if changes have been necessary.

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

20 July 2015

Professor L Hale
School of Physiotherapy
Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committees Office by no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Advise the Committee in writing as soon as practicable if the research project is discontinued.

Make no change to the project as approved in its entirety by the Committee, including any wording in any document approved as part of the project, without prior written approval of the Committee for any change. If you are applying for an amendment to your approved research, please email your request to the Academic Committees Office:

gary.witte@otago.ac.nz

jo.farronediaz@otago.ac.nz

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval or an extension of approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

Yours sincerely,

[Signature]

Mr Gary Witte
Manager, Academic Committees
Tel: 479 8256
Email: gary.witte@otago.ac.nz
Māori consultation: Chapter 5 and 6

Tuesday, 18 March 2014.

Associate Professor Leigh Hale,
School of Physiotherapy,
DUNEDIN.

Tēnā Koe Associate Professor Leigh Hale,

Postural stability in older adults with Alzheimer’s Disease

The Ngāti Tahu Research Consultation Committee (The Committee) met on Tuesday, 18 March 2014 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāti Tahu and the University. In the statement of principles of the memorandum it states “Ngāti Tahu acknowledges that the consultation process outlined in this policy provides no power of veto by Ngāti Tahu to research undertaken at the University of Otago.” As such, this response is not “approval” or “mandate” for the research, rather it is a mandated response from a Ngāti Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

“Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal.”

The Committee considers the research to be of importance to Māori health.

The Committee notes and commends that ethnicity data is to be collected using the questions on self-identified ethnicity and descent contained in the latest census.

The Committee suggests dissemination of the research findings to relevant Māori health organisations regarding this study, including Taeeora Timana, Māori Physiotherapists within the New Zealand Society of Physiotherapists.

We wish you every success in your research and the Committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18 month period from Tuesday, 18 March 2014 to 5 September 2015.
Nahaku noa, nā

Mark Brunton
Kaiwhakahaere Rakahau Māori
Research Manager Māori
Research Division
Te Whare Wānanga o Otago
Ph: +64 3 479 8758
Email: mark.brunton@otago.ac.nz
Web: www.otago.ac.nz
Tuesday, 14 July 2015.

Professor Leigh Hale,
School of Physiotherapy,
DUNEDIN.

Tēnā Koe Professor Leigh Hale,

Postural stability in older adults with memory loss.

The Ngāi Tahu Research Consultation Committee (the committee) met on Tuesday, 14 July 2015 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states “Ngāi Tahu acknowledges that the consultation process outlined in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago”. As such, this response is not “approval” or “mandate” for the research, rather it is a mandated response from a Ngāi Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee bases consultation on that defined by Justice McGechnan:

“Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon, adequately informing a party about relevant information upon which the proposal is based, listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal), understanding that each in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal.”

The Committee considers the research to be of importance to Māori health.

The Committee notes and comments that ethnicity data is to be collected using the questions on self-identified ethnicity and descent contained in the latest census.

The Committee suggests dissemination of the research findings to relevant Māori health organisations regarding this study, including Taiao Tītākia, Māori Physiotherapists within the New Zealand Society of Physiotherapists.

We wish you every success in your research and the committee also requests a copy of the research findings.

The Ngāi Tahu Research Consultation Committee has membership from:
Te Rūnanga o Otago Incorporated
Kīti Herenga Rūnaka i Paetaraaki
Te Rūnanga o Mokai
This letter of suggestion, recommendation and advice is current for an 18 month period from Tuesday, 14 July 2015 to 14 January 2017.

Nāhaku noa, nā

Mark Brunton
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Appendix B: Information sheets and consent

Information sheet for older adults with some memory loss and their family: Chapter 5 and 6

Postural Stability in Older Adults

Information sheet for older adults with some memory loss and their family

Principal Investigator: Associate Professor Leigh Hale
(leigh.hale@otago.ac.nz; tel: 479 5425)

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to consider and, if you wish, talk with relatives or friends, before deciding whether or not to participate.

If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the aim of this research project?

The project aims:

1. To investigate which of three ways of measuring balance and falls risk are best to use with older adults with some memory loss.
2. To find out what older adults with some memory loss think are the best ways for them to participate in an exercise programme to reduce their risk of falling.

We wish to develop an exercise programme that can reduce the number of falls that older adults with some memory loss have. But first we have to find out how best we can measure if someone with memory loss is at risk of falling. And secondly, we want
to know from older adults with some memory loss what factors would help them take part long term in an exercise programme.

**Who is funding this project?**

This study is funded by the University of Otago School of Physiotherapy funds.

**Who are we seeking to participate in the project?**

We are seeking 30 men and women with some memory loss who are aged over 65 years (or over 55 years old if they are Māori or a Pacific Islander). Volunteers should be independently mobile (with or without walking aid) and be able to understand the balance test instructions and take part in an interview. As we also need to collect information about the person’s health and their memory loss, we will ask participant’s permission to contact their general practitioner for this information.

**If you participate, what will you be asked to do?**

If you agree to participate in this study we will ask you to do two things (each activity will take about an hour to complete): (1) to have your balance tested, and (2) if possible, to take part in an interview. You may, if you wish, bring a support person to help you during the balance testing. If you are happy to be interviewed, we will ask if you could be accompanied, where possible, by the person who most supports you, for example, a family/whanau member, a caregiver or a support worker.

The balance test and the interview will take place at the most convenient place for you. It could be at rest home or at the Physiotherapy Balance Clinic. Please do advise us the place that suit you.

The balance tests you will be asked to complete are:
1. Posturography testing: we will ask you to do some simple movements whilst you stand on specialised equipment that measures the reactions of your feet whilst you move.

2. Timed Up and Go: This test evaluates your ability to stand up from sitting, walk 3m, turn around, and return to sitting.

3. Physiological profile assessment test: assesses common falls risk factors such as vision, sensation, muscle reaction time and balance.

In the interview we will have a conversation with you and your support person about your balance and what you think would be the best way that we can provide an exercise programme to improve your balance and reduce falls risk. We will also ask you a little bit about yourself and about your medical history. The interview will use an open ended question technique so that you can talk freely. We will audio record these interviews. The audio recording will then be written out word for word. You will have the opportunity to comment on your written interview if you wish to do so. We may contact you once more after the interview to clarify some of the points you made.

As mentioned above, the interviewing will use open-questioning technique of questioning. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the University of Otago Human Ethics Committee is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used. In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s) and also that you may withdraw from the project at any stage without any disadvantage to yourself of any kind.

We will provide you with a $25 grocery voucher to help reimburse your time, travel and/or parking costs.

Is there any risk of discomfort or harm from participation?

There should be no discomfort caused by any of the balance tests. The main risk of taking part in this study is during the balance testing when there is a slight risk of losing
balance while you are completing the tests. We will minimise this risk by ensuring the researchers testing you are trained in the safety requirements of the tests. If you feel unsure about attempting any test you can say you do not wish to complete that particular test.

If our balance testing shows that you are at risk of falling we will advise you to see your General Practitioner and we will give you a report to take with you. You can also share this report with staff at the rest home to help them support you better.

**What information will be collected, and how will they be used?**

The information from the balance tests will help us decide which test is best to use to see if someone is at risk of falling. The information from the interview will help us plan an appropriate exercise programme to help reduce your falls risk.

**What about anonymity and confidentiality?**

All information obtained from this study will be kept private and confidential. To make sure of this, you will be given a unique identifier.

Information used for any publication will be kept anonymous. The researchers and staff working on this project may have access to the data, but the data collected will be securely stored in such a way that only these people will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University’s research policy, any raw data on which the results of the project depend will be kept in secure storage for ten years, after which it will be destroyed, for example we will delete the interview audio-recordings.

Reasonable precautions will be taken to protect and destroyed data gathered by email. However, the security of electronically transmitted information cannot be guaranteed. Caution is advised in the electronic transmission of sensitive material.
If you agree to participate, can you withdraw later?

Participant in this study is entirely voluntary. You may withdraw from the project at any time without any disadvantage to yourself.

Any questions?

If you have any questions now or in the future, please feel free to contact either:

<table>
<thead>
<tr>
<th>Name: Leigh Hale</th>
<th>Contact phone number:</th>
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</thead>
<tbody>
<tr>
<td>Position: Deputy Dean</td>
<td>(03) 479 5425</td>
</tr>
<tr>
<td>Department: School of Physiotherapy</td>
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</table>

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<tr>
<th>Name: Normala Mesbah</th>
<th>Contact phone number:</th>
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<tbody>
<tr>
<td>Position: PhD student</td>
<td>(03) 479 5422</td>
</tr>
<tr>
<td>Department: School of Physiotherapy</td>
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</table>

This study has been approved by the University of Otago Human Ethics Committee (Health). If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (phone +64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
Information sheet for older adults with memory loss: Chapter 7

Postural stability in older adults with memory loss
Information Sheet for older adults with memory loss and their primary support person

Principal Investigator: Professor Leigh Hale (leigh.hale@otago.ac.nz; tel:4795425)

Thank you for showing an interest in this project. This is a doctoral student study. Please read this information sheet carefully. Take time to consider and, if you wish, talk with relatives or friends, before deciding whether or not to participate.

If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the aim of this research project?
This project aims to explore the feasibility and acceptability of delivering the modified Otago Exercise Programme (mOEP) for older adults with memory loss to reduce their falls risk and improve their balance (postural stability).

Who is funding this project?
This study is funded by the University of Otago School of Physiotherapy funds.

Who are we seeking to participate in the project?
We are seeking 10 men and women with memory loss who are over 65-years old (or 55-years old if they are Māori or Pacific Islander). Volunteers should be independently mobile (with or without walking aids) and able to understand verbal instruction sufficiently to safely undergo balance testing, to participate in the mOEP, and to take part in an interview. As we need to be sure that it is safe for you to participate in the exercise programme, we will ask your permission to contact your general practitioner to confirm your health status, to gain information about your memory loss, and to get medical clearance for you to participate safely.

If you participate, what will you be asked to do?
If you agree to participate in this study we will ask you to do 3 things:

1. To have your balance tested twice,
2. To participate in the exercise programme (mOEP) for once a week for 10 weeks,
3. If possible, to take part in one or two interviews.

You are welcome to bring a support person to help you during any part of the project.

The balance tests that you will be asked to complete are:
i. Timed up and go. This test evaluates your ability to stand up from sitting, walk 3m, turn around, and return to sitting.

ii. Timed up and go with counting. This test is the same as the test described above but this time you have to count backwards from 100 whilst you do the task.

iii. Physiological Profile Assessment test: this test assesses common falls risk factors such as vision, sensation, reaction time and balance.

iv. Step test: to measure how many times you can place one foot up and down on a small step in 30 seconds.

For the exercise programme (mOEP) you can choose whether you would like to do the mOEP with the physiotherapist on your own at home or as part of a group class at the School of Physiotherapy. The exercise programme is 30 minutes long (the time might vary depending on the ability of participants), and will be held once a week for 10 weeks.

In the interview we will have a conversation with you and your support person about how you found the exercise programme and whether you found it beneficial. We will also ask you if you have any suggestions to improve it. The interview will use an open ended question technique so that you can talk freely. We will audio record these interviews. The audio recording will then be written out word for word. You will have the opportunity to comment on your written interview if you wish to do so. We may contact you once more after the interview to clarify some of the points you made.

As mentioned above, the interviews will use an open-questioning technique of questioning. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the University of Otago Human Ethics Committee has not been able to review the precise questions to be used, in the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s) and also that you may withdraw from the project at any stage without any disadvantage to yourself of any kind.

Is there any risk of discomfort or harm from participation?

There should be no risk of discomfort caused by any of the balance tests or the exercise programme. There is a very slight risk that you might lose your balance whilst doing the tests or exercises but we will minimise this risk by ensuring the researchers testing and the physiotherapists delivering the exercise programme are well trained in the safety requirements of these tasks. The exercise programme will be delivered by two physiotherapists to ensure safe delivery. If you feel unsure about attempting any test or task in the exercise programme you can say you do not wish to complete that particular test or task.

What information will be collected, and how will they be used?

The information from the balance tests will help us evaluate the potential benefits of the exercise programme. The information from the interview will help us to evaluate the feasibility and acceptability (overall programme design) of delivering the mOEP, adherence to the programme and the safety of the mOEP.

What about anonymity and confidentiality?

All information obtained from this study will be kept private and confidential. To make sure of this, you will be given a unique identifier. Information used for any publication will be kept anonymous. The researchers
and staff working on this project may have access to the data, but the data collected will be safely stored in such a way that only these people will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University's research policy, any raw data on which the results of the project depend will be kept in secure storage for ten years, after which it will be destroyed, for example will delete the interview audio recordings.

Reasonable precautions will be taken to protect and destroy data gathered by email. However, the security of electronically transmitted information cannot be guaranteed. Caution is advised in the electronic transmission of sensitive material.

If you agree to participate, can you withdraw later?

Participation in this study is entirely voluntary. You may withdraw from the project at any time and without any disadvantage to yourself.

Any questions?
If you have any questions now or in the future, please feel free to contact either:

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<tr>
<th>Name</th>
<th>Contact phone number:</th>
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<tr>
<td>Leigh Hale</td>
<td>(03) 479 5425</td>
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<tr>
<td>Position: Dean</td>
<td></td>
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<tr>
<td>Department: School of Physiotherapy</td>
<td></td>
</tr>
<tr>
<td>Meredith Perry</td>
<td>(04) 385 5357</td>
</tr>
<tr>
<td>Position: Lecturer</td>
<td></td>
</tr>
<tr>
<td>Department: School of Physiotherapy</td>
<td></td>
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<tr>
<td>Norma Mesbah</td>
<td>(03) 479 5422</td>
</tr>
<tr>
<td>Position: PhD student</td>
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Information sheet for support person: Chapter 7

Postural stability in older adults with memory loss

Information Sheet for primary support person of older adults with memory loss

Principal Investigator: Professor Leigh Hale (leigh.hale@otago.ac.nz; tel:4795425)

Thank you for showing an interest in this project. This is a doctoral student study. Please read this information sheet carefully. Take time to consider and, if you wish, talk with relatives or friends, before deciding whether or not to participate.

If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the aim of this research project?
This project aims to explore the feasibility and acceptability of delivering the modified Otago Exercise Programme (mOEP) for older adults with memory loss to reduce their falls risk and improve their balance (postural stability).

Who is funding this project?
This study is funded by the University of Otago School of Physiotherapy funds.

Who are we seeking to participate in the project?
A person who is a family/whānau members, caregiver or support worker who is important and central to the care and support of the individual with mild to moderate cognitive impairment.

If you participate, what will you be asked to do?
If you agree to participate in this study we will ask you to take part in one or two interviews alongside the person you support. The interview will be held at the School of Physiotherapy, or at your home in agreement. In the interview we will have a conversation with you and your relative about your opinion of the exercise programme and its potential benefits. We will also ask you if you have any suggestions to improve it. The interview will use an open ended question technique so that you can talk freely. We will audio record these interviews. The audio recording will then be written out word for word. You will have the opportunity to comment on your written interview if you wish to do so. We may contact you once more after the interview to clarify some of the points you made.

As mentioned above, the interviews will use an open-questioning technique of questioning. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the University of Otago Human Ethics Committee has not been able of review the precise questions to be used. In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s) and also that you may withdraw from the project at any stage without any disadvantage to yourself of any kind.

360
Is there any risk of discomfort or harm from participation?
There should be no risk of discomfort.

What information will be collected, and how will they be used?
The information from the interview will help us to evaluate the feasibility and acceptability (overall programme design) of delivering the mOEP and the assessments, adherence to the programme and the safety of the mOEP.

What about anonymity and confidentiality?
All information obtained from this study will be kept private and confidential. To make sure of this, you will be given a unique identifier. Information used for any publication will be kept anonymous. The researchers and staff working on this project may have access to the data, but the data collected will be safely stored in such a way that only these people will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University’s research policy, any raw data on which the results of the project depend will be kept in secure storage for ten years, after which it will be destroyed, for example will delete the interview audio recordings.
Reasonable precautions will be taken to protect and destroy data gathered by email. However, the security of electronically transmitted information cannot be guaranteed. Caution is advised in the electronic transmission of sensitive material.

If you agree to participate, can you withdraw later?
Participation in this study is entirely voluntary. You may withdraw from the project at any time and without any disadvantage to yourself.

Any questions?
If you have any questions now or in the future, please feel free to contact either:

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact phone number</th>
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<tbody>
<tr>
<td>Leigh Hale</td>
<td>(03) 479 5425</td>
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<tr>
<td>Dean</td>
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<td>School of Physiotherapy</td>
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<tr>
<td>Norma Mesbah</td>
<td>(03) 479 5422</td>
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<tr>
<td>PhD student</td>
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<td>School of Physiotherapy</td>
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Consent form for participants with some memory loss: Chapter 5 and 6

Postural Stability in Older Adults
Consent form for participants with some memory loss

Principal Investigator: Associate Professor Leigh Hale
(leigh.hale@otago.ac.nz; tel: 479 5425)

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant:……………………………………

1. I have read the Information Sheet concerning this study and understand the aims of this research project.
2. I have had sufficient time to talk with other people of my choice about participating in the study.
3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.
4. All my questions about the project have been answered to my satisfaction, and I understand that I am free to request further information at any stage.
5. I know that my participation in the project is entirely voluntary, and that I am free to withdraw from the project at any time without disadvantage.
6. I know that as a participant
   • I will have balance tested at the rest home
   • and I may take part in an interview (also at the rest home).
7. I know that the interview will explore my opinions about my balance and the best ways to deliver an exercise programme to reduce my fall risk. I understand that if the line of questioning develops in such a
way that I feel hesitant or uncomfortable, I may decline to answer any particular question(s), and/or may withdraw from the project without disadvantage of any kind.

8. I know that I may bring whanau, a family member or a support person to support me during the balance testing and the interview.

9. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.

10. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.

11. I understand that the results of the project may be published and be available in the University of Otago Library, but I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study.

12. I know that no commercial use will be made of the data.

13. I know that there is no remuneration offered for this study, but I will be provided with a $25 grocery voucher to help with my travel expenses and time.

14. I agree that the researchers may contact my general practitioner to check on my medical history relating to health and memory loss.

YES ☐ NO ☐

Signature of participant: Date:

Signature and name of witness: Date:
Consent form for family/whanau/caregiver/support worker: Chapter 5 and 6

Postural Stability in Older Adults
Consent form (family/whanau/caregiver/support worker)

Principal Investigator: Associate Professor Leigh Hale

(leigh.hale@otago.ac.nz; tel: 479 5425)

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant:.............................................

1. I have read the Information Sheet concerning this study and understand the aims of this research project.
2. I have had sufficient time to talk with other people of my choice about participating in the study.
3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.
4. All my questions about the project have been answered to my satisfaction, and I understand that I am free to request further information at any stage.
5. I know that my participation in the project is entirely voluntary, and that I am free to withdraw from the project at any time without disadvantage.
6. I know that as a participant I will take part in an interview along with the person with some memory loss.
7. I know that the interview will explore my opinions about balance and the best ways to deliver an exercise programme to reduce fall risks. I understand that if the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s), and/or may withdraw from the project without disadvantage of any kind.
8. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.

9. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.

10. I understand that the results of the project may be published and be available in the University of Otago Library, but I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study.

11. I know that there is no remuneration offered for this study, but I will be provided with a $25 grocery voucher to help with my travel expenses and time.

12. I know that no commercial use will be made of the data.

Signature of participant: __________________________ Date: __________

Signature and name of witness: __________________________ Date: __________
Consent form for older adults with memory loss: Chapter 7

Postural stability in older adults with memory loss

Consent Form – participants with memory loss

Principal Investigator: Professor Leigh Hale (leigh.hale@otago.ac.nz; tel: 479 5425)

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant: ...................................................

1. I have read the Information Sheet concerning this study and understand the aims of this research project.
2. I have had sufficient time to talk with other people of my choice about participating in the study.
3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.
4. All my questions about the project have been answered to my satisfaction, and I understand that I am free to request further information at any stage.
5. I know that my participation in the project is entirely voluntary, and that I am free to withdraw from the project at any time without disadvantage.
6. I know that as a participant:
   • I will have my balance tested twice.
   • I will participate in the modified Otago Exercise Programme (mOEP) for 10 weeks,
   • and I may take part in one or two interviews.
7. I know that the interview will explore my opinion about the mOEP. I understand that if the line of questioning in the interviews develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s), and/or may withdraw from the project without disadvantage of any kind.
8. I know that I will be provided with a choice of exercise delivery of either group delivery at the School of Physiotherapy, or as an individualised programme at home.

9. I know that I may bring whānau, a family member or a support person to support me during the balance testing, the exercise programme, and the interview.

10. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.

11. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.

12. I understand that the results of the project may be published and be available in the University of Otago Library, but I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study.

13. I know that there is no remuneration offered for this study, and that no commercial use will be made of the data.

14. I agree that the researchers may contact my general practitioner to check on my medical history and general health and for eligibility to participate in the exercise programme.

Signature of participant: Date:

Signature and name of witness: Date:
Consent form for support person: Chapter 7

Postural stability in older adults with memory loss

Consent Form – family/whānau members, caregiver or support worker

Principal Investigator: Professor Leigh Hale (leigh.hale@otago.ac.nz; tel: 479 5425)

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant:......................................................

1. I have read the Information Sheet concerning this study and understand the aims of this research project.
2. I have had sufficient time to talk with other people of my choice about participating in the study.
3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.
4. All my questions about the project have been answered to my satisfaction, and I understand that I am free to request further information at any stage.
5. I know that my participation in the project is entirely voluntary, and that I am free to withdraw from the project at any time without disadvantage.
6. I know that as a participant I will take part in an interview along with the person with memory loss that I support.
7. I know that the interview will explore my opinion about modified Otago Exercise Programme. I understand that if the line of questioning in the interviews develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s), and/or may withdraw from the project without disadvantage of any kind.
8. I know that the interview will be held at the School of Physiotherapy, or at home.
9. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.

10. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.

11. I understand that the results of the project may be published and be available in the University of Otago Library, but I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study.

12. I know that there is no remuneration offered for this study, and that no commercial use will be made of the data.

Signature of participant:  

Date: 

Signature and name of witness:  

Date: 

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Appendix C: Questionnaires

General information questionnaire: Chapter 5 and 6

ID : AD ____________

Postural stability in older adult with memory loss

General Information Questionnaire

1. Are you?
   - [ ] Male
   - [ ] Female

2. When were you born?
   - Day: _______
   - Month: _______
   - Year: _______

3. What ethnic group do you belong to? Mark space/ spaces which apply to you?
   - [ ] New Zealand European
   - [ ] Maori
   - [ ] Samoan
   - [ ] Cook Island Maori
   - [ ] Tongan
   - [ ] Niuean
   - [ ] Chinese
   - [ ] Indian
   - [ ] Other (such as Dutch, Japanese, Tokelauan) please state __________________________
4. **What is your highest educational level attended?**

- [ ] High school or college
- [ ] Vocational or trade qualification
- [ ] Tertiary diploma or degree
- [ ] Other (please describe)

5. **Who is your primary support person is?**

   Name : ________________________________

   Address : ________________________________

   Phone : ________________________________

6. **When did you start noticing some memory loss?**

   Month   Year

   ______   ______

7. **Do you have any other medical condition(s) for which you are receiving treatment from your doctor?**

   - [ ] Yes (if yes, please go to question number 8)
   - [ ] No (if no, please go to question number 9)

8. **Please specify your other medical condition(s):**

   - [ ] High blood pressure (Hypertension)
   - [ ] Heart disease (All type of condition related to heart)
   - [ ] Lung disease
   - [ ] Diabetes
   - [ ] Depression
Musculoskeletal (e.g. arthritis, back pain, kyphosis, lordosis, )
Other (please specify)

9. How would you describe your walking ability?
   - Walking independently without walking aid
   - Walking independently with walking aid (please state type of walking aid you are using)

10. Have you have a history of fall(s) in last the 12 months?
    - Yes (if Yes, please go to question number 11)
    - No (if No, please go to question number 12)

11. How many fall(s) have you had in the last 12 months?
    A fall is defined as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level.
    - 1 fall
    - 2 or more falls

12. Medications

<table>
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<tr>
<th>No.</th>
<th>Name of medication</th>
<th>Frequency</th>
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</tbody>
</table>
13. The details of your General Practitioner?
   Name : _____________________________________________
   Address : ___________________________________________
   _____________________________________________

14. Would you like to receive information about the next study?
   [ ] Yes
   [ ] No
Diagnosing confirmation letter: Chapter 5 and 6

Date

Address

Dear Dr last name,

Postural Stability in People with Alzheimer’s disease study (H14/035)

We recruited participants with Alzheimer’s disease to be included in the above named study.

Study background: Falls are a frequent cause of hospitalization of people with Alzheimer’s disease; one reason for frequent falling is postural instability. In our study we wished to establish how best to measure changes in postural instability in people with Alzheimer’s disease and the optimal way to deliver an exercise intervention to them to reduce falls risk.

One of your patients volunteered to be a participant in our study. We would like to please confirm with you the diagnosis, if any, the patient has for their self-reported memory loss. Attached with this letter are:

1. A copy of consent form signed by your patient and
2. Diagnosis confirmation sheet.

We would be pleased if you could complete the attached form and return it to us in the pre-paid postage addressed envelope provided. Thank you – this is much appreciated.
Yours sincerely

Normala Mesbah
PhD Candidate
School of Physiotherapy
University of Otago

(Primary Supervisor: Professor Leigh Hale, Dean, School of Physiotherapy, Tel: (03) 479 5425, email: leigh.hale@otago.ac.nz)

leigh.hale@otago.ac.nz
It is confirmed that Participant name has been diagnosed with:

☐ Alzheimer’s disease (based on ________________________________
*criteria).

☐ Dementia

☐ Mild cognitive impairment

☐ I am unable to confirm any diagnosis relating to this person’s cognitive status

Signature : ________________

Name : ________________

Date : ________________

*Alzheimer’s disease diagnosis criteria

1. National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (NINCDS-ADRDA); OR
2. Diagnostic and Statistical Manual for mental disorder (DSM); OR
3. International Classification of Disease and Related Health Problems 10th Revision (ICD-10).
4. Others (stated).
Phone screening: Chapter 5 and 6

ID AD: _____________

**Process of Recruitment of Participants for Postural Stability in People with Alzheimer's disease study**

1. Send advertisements to the newspapers/Hospital/ Clinical centres, etc.
2. Volunteer phones School (Dr Marina).
3. Marina will check screening eligibility to participate (Telephone Recruitment Script).
4. If eligible, Marina will give Normals the address of the eligible participant to send him/her the following:
   a. Appointment letter.
   b. Baseline Questionnaire to be completed – which includes:
      i. Information sheet.
      ii. Consent form.
      iii. Demographics
   c. Pre-postage envelop (participation agreement)
5. Marina will give the participant an appointment to come to the School. She will tell the participant that an appointment letter and questionnaire will be posted to him/her.
6. Marina asks] please could you complete the questionnaire at home and bring it completed with them to the appointment.
7. [Marina asks] when are you best able to move around? (Best time for appointment to do the tests)
   Balance Clinic only available on (PwAD appointment schedule):
   - Tuesday, 9.00 a.m - 10.15 a.m.
   - Wednesday, 2.30p.m.
   - Friday, 2.30p.m.
8. Also need to book taxi or parking – as necessary.
   (NB: There should be a sufficient time for sending appointment letter and questionnaire before appointment).
9. On arrival, Normals:
   a. Will introduce and explain the procedure for the tests.
   b. Check if there are any questions.
   c. Make sure consent form is signed and check everything competed in the baseline questionnaire.
   d. Do the testing as described above.
   e. Schedule another visit for interview with Marina (PwAD appointment schedule).

Thank the patient and tell him/her will meet again for the interview.
Checklist to participant, remind to bring his/her

- Glasses
- Medication prescription
- Comfortable shoes + clothes
- Support person

It sounds like you are eligible. I will post you an information sheet and a questionnaire and give you an appointment at the School to be tested.

If once you have read the information sheet you feel that you do not want to participate in this study, please let me know and I will cancel your appointment. That will not be a problem.

Do you need me to book you a taxi or parking? The study can’t pay for your taxi fare, but we will provide $25 groceries voucher to help reimburse your travel and parking costs.

If ineligible..... Tell the participant that we are sorry..... but it will not be safe for them to participate / or they are too young!

Thank you for your time.....End the call

Telephone recruitment script: A general questions and MMSE.
Testing Scoring Sheet: Chapter 5 and 6

ID : AD ______

Postural Stability in Older Adults

Date : _______

Height (cm) : __________
Weight (kg) : __________

PPA and TUG scoring sheet

1. Edge contrast sensitivity (MET)
   Score ________

2. Reaction time – Hand

<table>
<thead>
<tr>
<th>Practice</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ms</td>
</tr>
<tr>
<td>2.</td>
<td>ms</td>
</tr>
<tr>
<td>3.</td>
<td>ms</td>
</tr>
<tr>
<td>4.</td>
<td>ms</td>
</tr>
<tr>
<td>5.</td>
<td>ms</td>
</tr>
<tr>
<td>6.</td>
<td>ms</td>
</tr>
<tr>
<td>7.</td>
<td>ms</td>
</tr>
<tr>
<td>8.</td>
<td>ms</td>
</tr>
<tr>
<td>9.</td>
<td>ms</td>
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<tr>
<td>10.</td>
<td>ms</td>
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</table>

3. Proprioception

<table>
<thead>
<tr>
<th>1.</th>
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<tbody>
<tr>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
</tr>
<tr>
<td>4.</td>
</tr>
<tr>
<td>5.</td>
</tr>
</tbody>
</table>

4. Strength

Knee extension

<table>
<thead>
<tr>
<th>kg</th>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
5. **Balance**

<table>
<thead>
<tr>
<th>Firm</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sway EO</td>
<td></td>
</tr>
<tr>
<td>Sway EC</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Foam</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sway EO</td>
<td></td>
</tr>
<tr>
<td>Sway EC</td>
<td></td>
</tr>
</tbody>
</table>

6. **Timed Up and Go test**

<table>
<thead>
<tr>
<th>TUG 1</th>
<th>s</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG 2</td>
<td>s</td>
</tr>
<tr>
<td>TUG 3</td>
<td>s</td>
</tr>
</tbody>
</table>

**Interview appointment**

**Date:**

**Time:**

**Venue:**
General information questionnaire: Chapter 7

Height : 
Weight : 

Postural stability in older adult with memory loss: Balance Wise

General Information Questionnaire

1. Are you?
   □ Male
   □ Female

2. When were you born?
   day  Month  Year
   _______  _______  _______

3. What ethnic group do you belong to? Mark space/ spaces which apply to you?
   □ New Zealand European
   □ Maori
   □ Samoan
   □ Cook Island Maori
   □ Tongan
   □ Niuean
   □ Chinese
   □ Indian
   □ Other (such as Dutch, Japanese, Tokelauan) please state

__________________________________________
4.  **What is your highest educational level attended?**

- [ ] High school or college
- [ ] Vocational or trade qualification
- [ ] Tertiary diploma or degree
- [ ] Other (please describe)

5.  **Who is your primary support person is?**

   Name : __________________________________________
   Address : ________________________________________
   Phone : __________________________________________

6.  **Roughly how long have you had problems with your memory?**

   Month   Year
   _______ - _________

7.  **Hearing aids?**

- [ ] Yes
- [ ] No

8.  **Glasses?**

- [ ] Yes  (Type of glasses) ____________________________
- [ ] No

9.  **What is your dominant arm?**

- [ ] Right
- [ ] Left
10. What is your dominant leg?
   - Right
   - Left

11. Do you have any other medical condition(s) for which you are receiving treatment from your doctor?
   - Yes (if yes, please go to question number 12)
   - No (if no, please go to question number 13)

12. Please specify your other medical condition(s):

   Years :
   - High blood pressure (Hypertension)
   - Heart disease (All type of condition related to heart)
   - Lung disease
   - Diabetes
   - Depression
   - Musculoskeletal (e.g. arthritis, back pain, kyphosis, lordosis, )
   - Other (please specify)

13. How would you describe your walking ability?
   - Walking independently without walking aid
   - Walking independently with walking aid (please state type of walking aid you are using)

14. What is your turning preferences?
   - Turn to right
   - Turn to left
15. **How many fall(s) have you had in the last 12 months?**

A fall is defined as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level.

- [ ] No fall
- [ ] 1 fall
- [ ] 2 or more falls

16. **Medications**

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of medication</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. **The details of your General Practitioner?**

Name : ________________________________

Address : ________________________________

18. **Do you participate with any programme/activity related with physical activity/exercises?**

- [ ] Yes *(please answer question 19-23)*
- [ ] No *(please answer question 22-23)*

19. **List all the programme/activity.**

__________________________________________

__________________________________________

__________________________________________
20. How many time per week?

________________________________________________________________________

21. How long each session?

________________________________________________________________________

22. Which group exercise you want to be part in?

☐ Individual tailored home based exercise
☐ Group exercise

23. Do you need transportation for the testing and group exercises programme?

☐ Yes
☐ No
Diagnosis confirmation and medical clearance letter: Chapter 7

Date

Name
Address

Dear Dr Last Name

**Otago Exercise programme for older adults with mild cognitive impairment**

We are currently undertaking a feasibility study exploring the feasibility and acceptability of delivering the modified Otago Exercise programme for older adults with memory loss to reduce falls risk and improve balance. This programme will be delivered individually at the person’s home or in a group at the School of Physiotherapy. Participants can choose which mode of delivery they prefer. The physiotherapy-supervised exercises will be done once a week for 10 weeks and will be of low level intensity and aim to strengthen lower limb muscles and improve balance.

*Name*, a patient of yours, has volunteered to be in our study and has consented for us to contact you to confirm that (1) this patient has Alzheimer’s disease / dementia / mild cognitive impairment and (2) is in your opinion medically safe to participate in the exercise programme. A copy of the consent form signed by your patient is attached.

We would be pleased if you could complete the attached form and return it to us in the pre-paid postage addressed envelope provided. Thank you – This is much appreciated.

Yours sincerely,

Professor Leigh Hale
Dean,
School of Physiotherapy,
University of Otago
Tel: 479 5425
leigh.hale@otago.ac.nz
Diagnosis confirmation sheet

Professor Leigh Hale
School of Physiotherapy
University of Otago
Tel: 479 5425
leigh.hale@otago.ac.nz

It is confirmed that **Name** has been diagnosed with:

- [ ] Alzheimer’s disease (based on _______________________________ *criteria).
- [ ] Dementia
- [ ] Mild cognitive impairment
- [ ] I am unable to confirm any diagnosis relating to this person’s cognitive status

**Medical clearance statement**

- [ ] I am happy for **Name** to participate
- [ ] I do not recommend **Name** participate
  
  because……………………………………………………………………

Signature : ______________
Name : ______________
Date : ______________

*Alzheimer’s disease diagnosis criteria

1. National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (NINCDS-ADRDA); OR
2. Diagnostic and Statistical Manual for mental disorder (DSM); OR
3. International Classification of Disease and Related Health Problems 10th Revision (ICD-10).
Clinical diary

This diary consisted 2 part: (1) Testing; and (2) modified Otago Exercise Programme. From this diary we would like to keep information related to:

- The practicality of the testing and the exercise programme
- The incident/ adverse events/ safety related to the testing and exercise programme
- Feedbacks/ comments from the participants related to testing and exercise programme

Please fill up the table below after each session of testing and exercise programme and submit this diary to Normala Mesbah after completed all testing.

Testing

<table>
<thead>
<tr>
<th>Date of testing</th>
<th>Comments / feedback / report of adverse events / safety /</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Modified Otago Exercise Programme

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Comments / feedback / report of adverse events / safety /</th>
<th>Number of participants attended</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>
In this diary we would like you to record each exercise that you have participated in each week for 10 weeks.

We would like you to record any adverse events at the end of each session.

Adverse events i.e. pain, discomfort, falls
# Otago Exercise Programme Weekly Diary

## Week 1

<table>
<thead>
<tr>
<th>Date: ____ / ____ / 20____</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Head movements</td>
<td></td>
</tr>
<tr>
<td>2. Neck movements</td>
<td></td>
</tr>
<tr>
<td>3. Back extension</td>
<td></td>
</tr>
<tr>
<td>4. Trunk movements</td>
<td></td>
</tr>
<tr>
<td>5. Ankle movements</td>
<td></td>
</tr>
<tr>
<td>6. Front knee strengthen (kg)</td>
<td></td>
</tr>
<tr>
<td>7. Back knee strengthen (kg)</td>
<td></td>
</tr>
<tr>
<td>8. Side hip strengthen (kg)</td>
<td></td>
</tr>
<tr>
<td>9. Calf raises</td>
<td></td>
</tr>
<tr>
<td>10. Toes raises</td>
<td></td>
</tr>
<tr>
<td>11. Heel toe stand</td>
<td></td>
</tr>
<tr>
<td>12. Walk and turn</td>
<td></td>
</tr>
<tr>
<td>13. Sideways walk</td>
<td></td>
</tr>
<tr>
<td>14. Sit to stand</td>
<td></td>
</tr>
<tr>
<td>15. Knee bends</td>
<td></td>
</tr>
<tr>
<td>16. One leg stand</td>
<td></td>
</tr>
<tr>
<td>17. Heel walking</td>
<td></td>
</tr>
<tr>
<td>18. Toe walking</td>
<td></td>
</tr>
<tr>
<td>19. Backwards walk</td>
<td></td>
</tr>
<tr>
<td>20. Heel toe walk</td>
<td></td>
</tr>
<tr>
<td>21. Stair walking</td>
<td></td>
</tr>
<tr>
<td>22. Heel toe walk backwards</td>
<td></td>
</tr>
<tr>
<td>Walking time (minutes)</td>
<td></td>
</tr>
</tbody>
</table>

**Comments/ adverse events:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

*each participant received a diary sheet until week 10*
Testing scoring sheet: Chapter 7

**Postural Stability in Older Adults with Memory Loss: Balance Wise**

**Pre programme**

<table>
<thead>
<tr>
<th></th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td></td>
</tr>
</tbody>
</table>

**PPA and TUG scoring sheet**

1. **Edge contrast sensitivity (MET)**
   - Score
   - Type of glasses:

2. **Reaction time – Hand**

<table>
<thead>
<tr>
<th>Practice</th>
<th>Test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

3. **Proprioception**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. **Strength**

<table>
<thead>
<tr>
<th>Knee extension</th>
<th>Right leg</th>
<th>Left leg</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. **Balance**

<table>
<thead>
<tr>
<th>Firm</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Foam

<table>
<thead>
<tr>
<th>AP sway EO</th>
<th>ML sway EO</th>
<th>AP sway EC</th>
<th>ML sway EC</th>
</tr>
</thead>
</table>

### 6. Timed Up and Go test

<table>
<thead>
<tr>
<th>TUG 1</th>
<th>s</th>
<th>Right turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG 2</td>
<td>s</td>
<td>Left turn</td>
</tr>
</tbody>
</table>

### 7. Timed Up and Go test (Cognitive)

Counting backward by 3s from a randomly selected number between 20 and 100

<table>
<thead>
<tr>
<th>TUG 1</th>
<th>s</th>
<th>Right turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG 2</td>
<td>s</td>
<td>Left turn</td>
</tr>
</tbody>
</table>

Numbers as counting 1:

### 8. Step test

<table>
<thead>
<tr>
<th>Score</th>
<th>steps</th>
<th>Right leg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>steps</td>
<td>Left leg</td>
</tr>
</tbody>
</table>

---

**Interview appointment (at week 5 intervention)**

Date: 

Time: 

Venue:
Post 10 weeks programme

Date: ______________

Height (cm): ______________
Weight (kg): ______________

PPA and TUG scoring sheet

1. Edge contrast sensitivity (MET)
   Score: __________ Type of glasses: __________

2. Reaction time – Hand
   Practice 1. _______ ms Test 1. _______ ms
   2. _______ ms 2. _______ ms
   3. _______ ms 3. _______ ms
   4. _______ ms 4. _______ ms
   5. _______ ms 5. _______ ms
   6. _______ ms
   7. _______ ms
   8. _______ ms
   9. _______ ms
   10. _______ ms

3. Proprioception
   1. __________
   2. __________
   3. __________
   4. __________
   5. __________

4. Strength
   Knee extension Right leg
   kg
   kg
   kg
   kg
   *dominant leg
   Left leg

393
5. **Balance**
   - Firm
     - Sway EO
     - Sway EC
   - Foam
     - Sway EO
     - Sway EC

6. **Timed Up and Go test**
   - TUG 1 [ ] s Right turn [ ]
   - TUG 2 [ ] s Left turn [ ]

7. **Timed Up and Go test (Cognitive)**
   - counting backward by 3s from a randomly selected number between 20 and 100
   - TUG 1 [ ] s Right turn [ ]
   - TUG 2 [ ] s Left turn [ ]
   - Numbers as counting 1:
   - Numbers as counting 2:

8. **Step test**
   - Score [ ] steps Right leg [ ]
   - Score [ ] steps Left leg [ ]

Interview & Testing appointment (at week 10)

Date:

Time:

Venue:
### Appendix D: Additional tables

Table D.1 Search strategy: Chapter 4

Search strategy

Table D.1 Database: Ovid MEDLINE(R) 1946 to Present with Daily Update

Search Strategy:

<table>
<thead>
<tr>
<th>Step</th>
<th>Search Term</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>postural stab*.mp.</td>
<td>1668</td>
</tr>
<tr>
<td>2</td>
<td>limit 1 to yr=&quot;2014 -Current&quot;</td>
<td>132</td>
</tr>
<tr>
<td>3</td>
<td>postural instability.mp.</td>
<td>1256</td>
</tr>
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<td>limit 3 to yr=&quot;2014 -Current&quot;</td>
<td>84</td>
</tr>
<tr>
<td>5</td>
<td>postural balance.mp. or Postural Balance/</td>
<td>15699</td>
</tr>
<tr>
<td>6</td>
<td>limit 5 to yr=&quot;2014 -Current&quot;</td>
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</tr>
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<td>7</td>
<td>balance.mp.</td>
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<td>8</td>
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<td>9</td>
<td>Balance control.mp.</td>
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<td>17</td>
<td>postural unsteadiness.mp.</td>
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<td>limit 17 to yr=&quot;2014 -Current&quot;</td>
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<td>equilibrium.mp.</td>
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<td>2777</td>
</tr>
<tr>
<td>21</td>
<td>posture.mp. or Posture/</td>
<td>65220</td>
</tr>
<tr>
<td>22</td>
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</tr>
<tr>
<td>23</td>
<td>body posture.mp.</td>
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<tr>
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<td>26</td>
<td>limit 25 to yr=&quot;2014 -Current&quot;</td>
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<tr>
<td>27</td>
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<td>31</td>
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<td>34</td>
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<td>alzheimer disease.mp. or Alzheimer Disease/</td>
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Non English Articles

Articles


Manual search articles

Articles


Table D.3: The comparison of descriptive analysis of all variables of postural stability measurements

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*Notes.* STS_WT, sit to stand weight transfer; STS_RI, sit to stand rising index; STS_SV, sit to stand sway velocity; WA_SW, walk across step width; WA_SL, walk across step length; WA_S, walk across speed; SQT TL, step quick turn time left; SQT TR, step quick turn time right; SQT SL, step quick turn sway left; SQT SR, step quick turn sway right; FiEOSV, firm eyes open sway velocity; FiECSV, firm eyes closed sway velocity; FoEOSV, form eyes open sway velocity; FoECSV, form eyes closed sway velocity; The discrepancy in sample was due to base on the number of participants who completed the test.
Appendix E: Interview schedules

Interview guide questions: Chapter 6

Topics to be explored will include:

1. Describe what your balance is or stability is like at a present?
   
   When you said………. can you explain further/
   
   What do you mean by saying ………………..

2. Describe any issue you have with your balance or stability.

3. Describe how you think exercise might benefit you.

4. How do you think exercise programme could be delivered to maximise participation and adherence?

5. What would help you to exercise regularly?

6. What would stop you from exercising regularly?

Tell me about your balance?

Tell me about the times you have lost your balance or nearly had a fall?

How do you think you could improve your balance?

*no mention of exercise: How do you think exercise might help you?

What would help you to do regular exercise?

Where would you like to do the exercise?

What thing would stop you doing regular exercise?
Interview schedule: Chapter 7

- In this interview I would like to seek your opinions about the exercise class.
- The interview will use an open ended question technique so that you can talk freely.
- Feel free to say no if you feel that you don’t want to answer any of the questions.
- We will audio record these interviews.
- The audio recording will then be written out word for word but you will remain anonymous in it.
- You will have the opportunity to comment on your written interview if you wish to do so.
- We may contact you once more after the interview to clarify some of the points you made.

What does Christmas mean to you?

Can you tell me how is your memory at the present?

Tell me about the things that you do to assist your memory?

Describe for me difficulties you have when talking to people.

Please tell me about the exercise program you have just completed?
  - When you said .......... can you explain more?
  - How did you feel being in this study?

In a first part of the exercise, you did in the group and then there was a break we gave you the diary and also the booklet of the exercises program and you do it by your own and then we continue again the exercise program in the group. Can you tell me the differences you found between in the group and as individual exercise?

What do you think about the diary?

Can you tell me about the exercise file that has been given to you?

At the first instant can you tell me why you want to participate in this program?

What is your expectation?

Did the program meet your expectation?

If No, can you explain more....

If Yes, can you elaborate more....

404
**Carers:** Can you tell me the meaning for you to getting involved in activities outside the home accompany your spouse doing group exercise?

And what do you believe getting involved in activities outside the home means for a person with memory issue?

Can you tell me your feeling be in the exercise group?

Can you tell me your feeling when you come out from house do exercise and meeting with new people?

How easy/ hard was the programme?

Do you think 30 minutes for exercise is enough?

What do you think about the activity that we did for brain stimulation (for example: counting money)套餐？

What motivated you to participate in the programme?

What things would make it hard for you to come to the program (for example: weather)?

- Can you tell me during the day that participant name seems not willing to come for exercise?/ miss the class. (withdrawal/anxiety a feeling of worry, nervousness, or unease about something with an uncertain outcome)

What were the reasons (if any) for ceasing/ stopping the programme/ from doing the exercises? /

Do you think that the exercise is safe?

- Can you tell me any adverse event/ side effect from the exercise program?

What would you like to change about the program to suit you better? /

As you know this exercise is a structured exercise and all of you have been given the same exercises, does it fit you well?

How usually you come here for the exercise?

(Car) Is he always available to send you here?

(public transport) can you tell me your experience taking bus coming here for exercise?

Can you tell me about the music that we played during the exercise?

Can you tell me your relationship with other members in the exercise program?

Can you tell me your opinion about the instructor?
How confident you are now with your balance?

There is one say that, the exercise program should be **based on the ability** of each individual, what your opinion about this statement?

There is one say that, exercise program help he/she is term of social interaction, how about you?

Special question based on medical history reported by participant

Will you continue to exercise?
Why? Why not?
Appendix F: Advertisement

Advertisement: Chapter 5 and 6

Postural stability in older adults with memory loss

In this research we wish to explore the feasibility and acceptability of delivering the modified Otago Exercise programme for older adults with memory loss to reduce falls risk and improve balance. We would also like to explore participants’ opinion of the programme.

We are seeking older adults aged 65 years plus (or 55 years plus if Māori or Pacific Islander) who are experiencing problems with their memory. Volunteers should be independently mobile (with or without walking aids) and able to understand instructions to safely undergo balance testing, and participate in the exercise programme and when possible with family, whānau members, caregiver or support worker for interviews.

Balance tests, the exercise programme and the interviews will each take about 30-60 minutes but will not occur on the same day. You will be provided with a choice of exercise delivery of either group delivery at School of Physiotherapy, or as an individualised programme at home. For individualised programme the date and time are at your own choice starting from 21st September until 11th December 2015. For group delivery at School of Physiotherapy it will be held on every Thursday from 10-11 am, starting from 24th September until 10th December 2015.

Principal Investigator:
Leigh Hale, School of Physiotherapy, tel: 4795425, leigh.hale@otago.ac.nz

Should you wish to take part in this research please contact

The Clinical Research Administrator
Email: clinica.research.physio@otago.ac.nz
Tel: (03) 497 4979

This project has been reviewed and approved by the University of Otago Human Ethics Committee, (Health). Reference: H15/073]
Postural stability in older adults with Alzheimer’s Disease

In this research we wish to investigate which methods of measuring balance and falls risk are best for older adults diagnosed with Alzheimer’s disease. We would also like to explore what they think are the best ways for them to participate in an exercise programme to reduce their risk of falling.

We are seeking older adults aged 65 years plus (or 55 years plus if Maori or Pacific Islander) diagnosed with Alzheimer’s disease. Volunteers should be independently mobile (with or without a walking aid), be able to understand the balance test instructions, and be able to participate in an interview with support.

We will provide $25 grocery vouchers to assist in reimbursing travel costs.

Balance testing and interviews will take about one hour each but need not occur on the same day.

Balance will be tested in the School of Physiotherapy.

Principal Investigator:
Leigh Hae, School of Physiotherapy,
Tel: 479 5425, leigh.hae@otago.ac.nz

Should you wish to take part in this study please contact:
The Clinical Research Administrator
Email: clinicalresearch.physio@otago.ac.nz
Tel: (03) 479 4979

This project has been reviewed and approved by the University of Otago Human Ethics Committee. Ref: H14/038
Appendix G: Agreement

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Mar 23, 2018

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Noura Mesbah
(Print name)
22 Nov 2018
Date

Kristen Melly
(Print name)
11/22/18
Date

Natus Medical Incorporated 1501 Industrial Rd., San Carlos, CA 94070-1111 Tel: 650-852-0400 Fax: 650-852-0401
Re: Permission to use PPA picture in the thesis

Sandra O. Rourke <s.orourke@neura.edu.au>
Wed 21/11/2018 4:04 p.m.
To: Normala Mesbah <normala.mesbah@postgrad.otago.ac.nz>

Yes all good

---

From: "Normala Mesbah" <normala.mesbah@postgrad.otago.ac.nz>
To: "Sandra O. Rourke" <s.orourke@neura.edu.au>
Sent: Wednesday, November 21, 2018 1:49:44 PM
Subject: Permission to use PPA picture in the thesis

Dear Sandra O. Rourke,

Greetings,

This email is regarding getting a permission to use PPA picture in the thesis.

My thesis title is Postural Stability in older adults with Alzheimer’s disease (https://www.otago.ac.nz/physio/research/OTAGO11030). There was a suggestion by one of the examiner to insert PPA picture in the thesis. Can you help me how to get the permission please.

Attached is the picture that I would like to use.

Many thanks and have a nice day.

Kind regards,
Normala

---

Balance and memory loss, Research, School of Physiotherapy, University of Otago, New Zealand

https://outlook.office365.com/owa/7/path?mailsearch
Appendix H: Poster

Poster presentation

Falls prevention programme: What exercise characteristics matter to older adults with memory loss

Normala Meskele\textsuperscript{a}, Professor Leigh Hale\textsuperscript{b}, Dr Meredith Perry\textsuperscript{c}, Professor Keith Hill\textsuperscript{d}

1. School of Physiotherapy, University of Otago, New Zealand
2. School of Rehabilitation Sciences, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Malaysia
3. School of Physiotherapy and Exercise Science, Currin University, Australia (Advisor)

DID YOU KNOW THAT...

- An exponential rise in the number of older adults with cognitive impairment is predicted
- Postural instability is a problem for this population
- Evidence for the use of exercise to improve postural stability is less robust
- This diversity may be due to the delivery of the exercise programme

OUR AIM

To explore the important features of an exercise intervention to improve postural stability

1. Good acceptance
2. Uptake
3. Adherence

WHAT WE DID WAS...

- Design: Qualitative study (part of a parallel mixed method design)
- Intervene in older adults with cognitive impairment and six support persons
- Recruit from community and day care programme
- Analyse the data based on General Inductive Approach

OUR PARTICIPANTS

Table 1: Characteristics of older adults with cognitive impairment

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<td>Age, mean (SD)</td>
<td>80.50 (7.96)</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>n / s</td>
</tr>
<tr>
<td>Ethnicity, n</td>
<td>NZ European, 8</td>
</tr>
<tr>
<td></td>
<td>Australian, 1</td>
</tr>
<tr>
<td>Education, n</td>
<td>High school, 5</td>
</tr>
<tr>
<td></td>
<td>University, 5</td>
</tr>
<tr>
<td>History of falls, n</td>
<td>2</td>
</tr>
<tr>
<td>MMSE*, mean (SD)</td>
<td>21.55 (4.32)</td>
</tr>
</tbody>
</table>

*MMSE: Mini Mental State Examination

Results were approved by ORC009 (Ethics ID: 2010/001; 2010/001)

Acknowledgments
School of Physiotherapy, University of Otago
Southern Physiotherapy Symposium 7

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