The development of a validated falls risk assessment for use in clinical practice

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The development of a validated falls risk assessment for use in clinical practice

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Declaration

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgment is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.

Signed…………………………………………………………….

Date……………………………………………………………….

Abstract

Falls risk factor assessment is the first step in the development of appropriate intervention strategies for the prevention of falls. However, few multifactorial, validated falls risk assessments exist which are suitable for use in busy clinical settings. This project aimed to develop a reliable and valid falls risk assessment that was feasible for use in various clinical settings. The QuickScreen Clinical Falls Risk Assessment was developed and evaluated via four methods; a) the test-retest reliability of the measures was assessed with 30 community-dwelling older people, b) the concurrent validity of the measures was assessed by comparison with performance in the Physiological Profile Assessment, c) the predictive validity of the measures was assessed by comparison of performance with prospective falls in two studies involving large samples of community dwelling older people and d) the feasibility of the assessment was evaluated with 40 clinicians who trialled the assessment with their patients. The QuickScreen clinical falls risk assessment consists of eight measures, including previous falls, total medications, psychoactive medications, visual acuity, touch sensation, the sit to stand test, the near tandem stand test and the alternate step test. The test-retest reliability of the assessment measures was acceptable (intra-class correlation coefficients ranged from 0.56 to 0.89) and the assessment measures discriminated between multiple fallers and non-multiple fallers with relative risk values ranging from 1.4 to 2.5. The clinicians that trialled the assessment reported that it was quick and easy to administer and that it assisted in the management of their elderly patients. These results show that the QuickScreen Clinical Falls Risk Assessment has proven validity, test-retest reliability and is practical for use in a variety of clinical settings.

Table of Contents

Chapter 1. Introduction ……………………………………………………….. 1

1.0 1.0 Thesis aims……………………………………………………….....................
1

1.1 Background………………………………………………………………. 3

- Epidemiology of falling………………………………………………………… 3
- Falls injuries……………….…………………………………………………… 3
- Economic cost of falls……..…………………………………………………… 5
- Fall risk factors……………………………………………………….............. 6
- Fall risk assessment…………………………………………………………… 7

1.2 Thesis outline………………………………………………………………. 9

Chapter 2. Background……………………………………………………….. 11

2.0 Risk factors for falls…………………………………………………………... 11

2.1 Sensorimotor and balance factors……………………………………………….. 11

2.2 Medical risk factors……………………………………………….………... 12

2.3 Environmental risk factors……………………………………………............ 13

2.4 Demographic and psychosocial risk factors……………………………..……….. 13

2.5 Risk factor assessment……………………………………………………….... 14

- Single question/ questionnaire falls risk assessments…………….……………. 15
- Single risk factor assessments which require minimal or no equipment………. 18
- Functional falls risk assessments……………………………….…………… 26
- Multifactorial falls risk assessments……………………………………........... 36

2.6 The role of general practitioners in falls prevention…………………………….. 44

2.7 The role of allied health professionals in falls prevention………………………. 48

2.8 Fall risk assessment carried out by clinicians in previous research……………… 49

2.9 Barriers associated with preventative health care in the clinical setting………… 52

Chapter 3. Rationale for the study………………………………………… 57
3.0 Why was this study needed? ………………………………………............ 57
3.1 The Physiological Profile Assessment……………………………………... 59
3.2 Clinical falls risk assessment measures- rationale for selection and test descriptions.. 62
3.3 Construct validity of the strength, balance, reaction time and mobility tests- study rationale………………………………………………………………. 73
3.4 Methods……………………………………………………………...…. 74
- Subjects…………………………………………………………………….. 74
- Physiological profile assessment measures………………………............ 76
- Statistical analysis…………………………………………………….. 87
3.5 Results……………………………………………………………………….. 88
3.6 Discussion………………………………………………………………… 97

Chapter 4. Test-retest reliability study…………………………………… 101
4.0 Aim………………………………………………………………….......... 101
4.1 Background……………………………….…………………………….. 101
4.2 Methods……………….……………………………………………………… 101
- Subjects……………………………..………………………………….. 101
- Assessment measures……………………………………………...…... 103
- Test-retest assessment protocol……………………………………….. 104
- Statistical analysis……………………………………..………………. 104
4.3 Results……………………………………………………………….......... 105
4.4 Discussion……………………………………………………………...….. 106

Chapter 5. Functional balance and mobility tests- External validity studies. 110
5.0 Aims…………………………………………………………….............. 110
5.1 Background…………………………………………………………........... 110
5.2 Methods……………………………………………………………….……… 111

- Subjects…………………………………………………………………......... 111
- Assessment measures……………………………………………………….. 114
- Falls surveillance…………………………………………………………. 114
- Statistical analysis………………………………………………………… 115
5.3 Results- first external validity study…………………………………………….. 116
5.4 Results- second external validity study……………………………….………. 120
5.5 Discussion………………………………………………………………………….. 122

Chapter 6. Clinical falls risk assessment tool- External validity study..…. 127
6.0 Aim……………………………………………………………………….... 127
6.1 Background……………………………………………………………........... 127
6.2 Methods……………………………………………………………………. 127
- Subjects…………………………………………………….……….. 127
- Assessment measures……………………………………………………….. 131
- Falls surveillance………………………………………….………… 131
- Statistical analysis…………………………………………………......... 131
6.3 Results………………………………………….…………………........... 133
6.4 Discussion……………………………………………………………….……. 136

Chapter 7. The Feasibility study………………………………………. ….. 139
7.0 Aim………………………………………………………………………. 139
7.1 Background………………………………………………………….............. 139
7.2 Refinement of assessment tool………………………………………………… 139
7.3 Feasibility study methods…………………………………………………… 148
- Subjects…………………………………………………………............ 148
- Follow-up evaluation……………………………………………………… 148
7.4 Results…………………………………………………………………........... 149
7.5 Other settings where the assessment has been implemented into clinical practice. 154
7.6 Discussion………………………………………………………………………… 160

Chapter 8. Discussion and conclusion………………………………………… 163
8.0 Overview of main study findings……………………………………………… 163
8.1 Limitations of the study design………………………………………………... 165
8.2 Strengths of the study design…………………………………….………… 167
8.3 Implications for clinical practice and public health policy………...……………. 169
8.4 Conclusion………………………………………………………………….. 171
References…………………………………………………………………... 172
Appendix…………………………………………………………………. 194
- Falls and medical care calendar……………………………............................. 194
- QuickScreen Clinical Falls Risk Assessment testing instructions………………... 195
- Patient education sheets included in the QuickScreen Assessment kit…………… 198
- Home exercise booklet included in the QuickScreen Assessment kit……………. 202.
- AARN falls risk assessment and prevention project evaluation report.................. 207
- RCNA General Practice Nurse workshop- falls prevention and assessment education. Master pre and post workshop survey……………………………………. 226
- Research papers that have arisen from this thesis………………………………… 233

List of tables

Table 2.1: Falls risk assessment measures used in previous research…………………… 42
Table 3.1: Age and sex distribution (number (%)) of the sample in the construct validity study……………………………………………………………………………… 75
Table 3.2: Prevalence of major medical conditions and ADL limitations in the subjects of the construct validity study…………………………………………………… 75
Table 3.3: The means and standard deviations for performance in the physiological tests and the functional tests……………………………………………………………… 89
Table 3.4: Correlations between the functional tests and physiological measures……… 91
Table 3.5: Multiple regression model for the sit to stand test with five repetitions……... 92
Table 3.6: Multiple regression model for the sit to stand test with one repetition………. 93
Table 3.7: Multiple regression model for the rod catch test……………………………... 93
Table 3.8: Multiple regression model for the near tandem stand test…………………..… 94
Table 3.9: Multiple regression model for the half turn test……………………….……… 94
Table 3.10: Multiple regression model for the alternate step test……………………..…. 95
Table 3.11: Multiple regression model for the six metre walk test…………………..…... 96
Table 4.1: Prevalence of major medical conditions and ADL limitations obtained from self-report in the reliability study sample……………………………..…………….…….. 102
Table 4.2: Means (SD) of test performance for each continuous variable across the two measurement sessions……………………………………..……………………… 106
Table 5.1: The age and sex distribution [number (%)] of the subjects in the initial external validity study…………………………………………………………...…… 111
Table 5.2: Prevalence of major medical conditions and limitations in activities of daily living in the subjects in the initial external validity study……………………………..... 112
Table 5.3: The age and sex distribution [number (%)] of the subjects in the second external validity study…………………………………………………...………… 113

Table 5.4: Prevalence of major medical conditions and limitations in activities of daily living in the subjects in the second external validity study………………………… 113
Table 5.5: Comparison of performance in the functional tests between men and women.. 117
Table 5.6: *T*-test comparing performance in the assessment measures between multiple fallers and non-multiple fallers…………………………….……………… 118
Table 5.7: ROC curve analysis results for predicting multiple fallers…………………… 119
Table 5.8: The results of the principal components factor analysis……………………… 119
Table 5.9: Ability of test measures to predict multiple fallers in the follow-up study…… 121
Table 6.1: Characteristics of the four cohorts- demographics, prevalence of major medical conditions and limitations in activities of daily living (ADLs)………………..… 130
Table 6.2: *T*-test comparing performance in the continuously scored assessment measures between multiple fallers and non-multiple fallers……………………………… 134
Table 6.3: Test performance criteria for predicting multiple fallers……………………... 135
Table 6.4: The Odds Ratio scores which correspond to the number of risk factors identified by the clinical fall risk assessment……………………………………………... 136
Table 7.1: The results of the clinician evaluation survey………………………………… 150
Table 7.2: Prevalence of risk factors in the patients assessed by the clinicians in the feasibility study (number [%])………………………………………………………… 153

List of figures

Figure 3.1 Physiological factors that are the primary contributors to stability and some common methods used to assess them…………………………………………… 60

Figure 3.2: The sit to stand test……………………………………………………... 63

Figure 3.3: The rod catch test……………………………………………………….. 65

Figure 3.4: The near tandem stand test, body and foot positioning………………………. 67

Figure 3.5: The alternate step test…………………………………………………… 69

Figure 3.6: The low contrast visual acuity chart………………………………………. 71

Figure 3.7: The tactile sensitivity test………………………………………………. 72

Figure 3.8: The high and low contrast visual acuity chart……………………………….. 76

Figure 3.9: The Melbourne Edge Test…………………………………………….….. 77

Figure 3.10: The depth perception apparatus and test position…………………............. 78

Figure 3.11: The proprioception test…………………..…………………………………… 79

Figure 3.12: The vibration sense test……………………………………………….. 80

Figure 3.13: The knee extensor strength test …………………..……………………… 82

Figure 3.14: The knee flexion strength test…………………………………………… 82

Figure 3.15: The ankle dorsiflexion strength test……………………………………... 83

Figure 3.16: The foot reaction time test…………………………………………......... 84

Figure 3.17: The hand reaction time test……………………………………………… 84

Figure 3.18: Postural sway assessment using the sway meter………………..………. 85

Figure 3.19: The co-ordinated stability test standing position and race track…………... 87

Figure 5.1: Relationship between the number of mobility tests with poor performance and the Odds Ratio for multiple falls……………………………………….. 120

Figure 7.1: The QuickScreen assessment form………………………………………... 145

Chapter One

Introduction

1.0 Thesis Aims

This project aimed to develop a validated falls risk assessment which was suitable for use in clinical settings. To achieve this, the following tasks were undertaken:

1. A reliability study to determine the test-retest reliability of a set of possible tests for measuring risk factors for falls in older people. Reliability can be defined as the consistency of measurements or of an individual's performance on a test [1] or the absence of measurement error [2]. Test-retest reliability is an important consideration when tests are being selected to assess physical performance and change in function over time since the reliability of a test is a reflection of how dependable the measures are as a true reflection of the actual physical status of the individual being assessed. This is particularly important if the tests are to be used to determine a change in function over time, for example, this may be an improvement in performance as a result of an intervention or deterioration in performance due to a disease state or to the ageing process.

2. Three validity studies: the first aimed to determine the construct validity of the assessment measures when compared to the Physiological Profile Assessment, a previously validated battery of tests which measure common physical falls risk factors. The second study aimed to determine the external validity of the assessment measures as falls risk predictors in a sample of older people and the third aimed to determine the

external validity of the final falls risk assessment for predicting falls in an individual patient data meta-analysis of four study samples. Validity is a crucial aspect of any falls risk assessment since it shows that the outcome of the assessment has a significant association with risk of falling.

3. A feasibility study to determine the appropriateness of the falls risk assessment for use by general practitioners, physiotherapists and nurses in a range of clinical settings with elderly patients. Feasibility is an important consideration in the design of assessment tools for clinicians to use, since the assessment will only be used regularly if it is acceptable to those people that it is designed for, irrespective of the evidence of its reliability and validity.

1.1 Background

Epidemiology of falling

Increased susceptibility to falling is one of the most serious and costly problems associated with ageing. Approximately one third of people aged 65 years and over living in the community fall at least once a year, with between 11% and 17% of these people suffering multiple falls [3, 4, 5, 6]. It has been estimated that at least 40% of people who have been hospitalised because of a fall are discharged to nursing home care and a further 10% of people need ongoing assistance at home from community services [7]. The rate of falling in institutionalised older people is even higher with studies reporting fall rates of between 40% and 56% in elderly residents each year [8, 9].

Injury prevention and control, which includes falls injury prevention, is one of six National Health Priority Areas established by the Australian Health Ministers in 1994 and is a major focus of much current research in Australia. This research aims to develop strategies for ensuring a healthy elderly population since there are currently more than 2.5 million people in Australia aged 65 years and over and by the year 2101, estimates show that there will be between 6.1 and 11.7 million people in this demographic category, representing a proportionate increase from 13% to between 29% and 32% of the population [10]. Implications for successful public health strategies for older people include improved quality of life and reduced health care costs for the community.

Fall Injuries

Falls are the leading cause of injury-related death and hospitalisation in persons aged 65 years and over [11]. In 1998 in Australia there were 1014 deaths as a result of falls in people aged

65 years and over [12], which equated to a population-adjusted rate of 38.9 deaths per 100 000 people. The death rate increased with increasing age, with the highest rate occurring in the 85 years and above age group. Between 22% and 60% of falls result in injury, depending on the population under study [13, 14] and it has been estimated that 20% of people who experience a fall sustain injuries that require medical attention [15, 16] including treatment by general practitioners, emergency departments and admission to hospital [17]. Major injuries, including soft tissue damage, head trauma, dislocations and fractures, occur in 5 to 15 % of all falls in any given year.

Fracture to the neck of the femur is one of the most serious injuries resulting from a fall and occurs in approximately 1% to 2% of falls [4, 5, 18]. Of the people who sustain a hip fracture, many fail to regain their pre-fall level of functioning and in one study [19] it was found that 18% of people who sustained a fractured femur had died within six months of the injury occurring and 29% had been institutionalised. If current trends in injury rates are applied, it is projected that by the year 2026 the number of hip fracture patients each year will double and by 2051 there will be a four-fold increase [20], creating a huge demand for health services and residential aged care places.

Australian fall-related hospital data [12] show hospitalisation rates for falls are significantly higher for females compared with males and the rate for both men and women increases exponentially with age. There is a nine-fold increase in the rate of hospitalisation from age 65 years to age 85 years and above. The data also show that the death rate as a result of accidental falls increases with increasing age, peaking in the 85 years and above age group.

Apart from the possibility of serious injuries, falls can result in permanent disability, restriction of activity, loss of confidence and fear of falling - all of which reduce quality of life and independence. Over time this can lead to a reduction in physical activity, which can in turn lead to a higher risk of future falls [21]. Furthermore, as mentioned above falls can contribute to the placement of an older person into a residential aged care facility [7, 22].

Economic cost of falls

There are many costs associated with falls which may be classified as direct or indirect costs. Direct fall-related costs can include hospital and nursing home care, doctor and allied health care services, diagnostic tests, medications and home modifications. Indirect costs include informal carer costs often provided by friends and/or family, patient opportunity costs and patient mortality and morbidity costs as well. In economic terms, these costs are large and will grow as the proportion of older people residing in Australia grows [23, 24].

A report prepared for the Australian Government [25] found that the ageing of the Australian population will have a significant impact on the Australian health system due to the increased number of older people suffering fall related injuries. By 2051, the total health cost attributable to fall related injury will increase almost three fold from current levels to $1,375 million per annum if age-specific falling rates remain unchanged. 886,000 additional hospital bed days or the equivalent of 2,500 additional beds permanently allocated to falls injury treatment will be required for the increased demand and 3,320 additional nursing home places will be required. The report concluded that to maintain cost parity over this period, prevention strategies will need to deliver approximately a 66% reduction in falls incidence. In addition, it is interesting to note that the cost to the health system of fall injury in NSW exceeds all other causes of injury, including road trauma [26]. This and the other statistics presented above, point to the urgency for health professionals to be provided with the knowledge and skills to implement effective falls prevention strategies in the course of their usual patient care.

Fall risk factors

Extrinsic or environmental factors play a role in fall causation and injury, however the majority of falls are thought to be due to the interaction between extrinsic and intrinsic factors [27]. It is widely accepted that the risk of falling increases as the number of risk factors present increases. In a community-dwelling cohort, for example, the risk of falling ranged from 8 % among those people with no risk factors to 78 % for people with four or more risk factors [5].

Several physiological factors that are associated with an increased risk of falling have been identified through large prospective studies [5, 28]. These include poor vision, reduced lower limb strength, slow reaction time, reduced proprioception and touch sensation in the lower limbs and increased body sway. People who fall are more likely to possess one or more of these deficiencies than their non-falling peers, which may result from an underlying specific disease or merely from the effects of the ageing process. The effects of certain chronic medical conditions can also place an older person at risk of falls as can the using of certain medications. There are also psychosocial and demographic factors that are associated with a greater risk of falling. These risk factors are discussed in more detail in chapter two.

Falls Risk Assessment

Early identification of falls risk and training of health workers in falls risk factor screening and management are two of the recommendations for future research that arose from a report commissioned by the Australian Government [29], which aimed to summarise the research evidence regarding effective strategies to reduce falls and fall injuries in older people. Identification of falls risk and consequent intervention is an effective method of preventing falls in the elderly, in both people who have fallen previously and in those who have not [30]. Falls risk increases as a result of the cumulative effect of multiple disabilities and deficiencies, therefore the aim of a clinical evaluation should be to identify modifiable risk factors and hence implement remedial strategies for the prevention of injury and disability. Risk assessments can highlight disease risk factors and allow appropriate interventions to be implemented and by detecting impairments in individuals at an early stage, interventions may be able to slow the decline in function in key physiological systems and therefore reduce the incidence of falls.

To be a valuable resource, any risk assessment needs to meet certain criteria. Importantly, it needs to have demonstrated validity; which means that there is evidence to suggest that it actually measures what it is intended for. The tool also needs to be reliable, so that the results obtained can be considered a true reflection of the individual's level of ability or functioning, and can be used to monitor progress over time. Lastly, the risk assessment needs to be acceptable to those being assessed and to those performing the assessment. In the context of a falls risk assessment for health care practitioners, this means that an assessment needs to be of short duration so that it can be carried out in a standard length consultation. It should also require little or no equipment and be easy to understand and safe for an elderly person to undergo.

This thesis documents the development of a falls risk assessment that allows for the measurement of an individual's risk of falling and includes recommendations for the implementation of intervention strategies. The specific stages of the development of the assessment tool included an investigation of test-retest reliability, an analysis of the validity of the assessment for falls prediction and the concurrent validity of the measures compared to other validated falls risk measures and lastly a study of the feasibility of the assessment tool for use in clinical settings with elderly patients. General practitioners (GPs) were the first health care group chosen to trial the assessment tool because they play an important role in the lives of many older people and are the first point of contact for an elderly person at risk of falls. GPs see 80% of the Australian population at least once every 12 months and deal with all health problems either directly or by referral. The feasibility study was extended to include other health professionals who are likely to have contact with older people and who may be able to facilitate the prevention of older people's falls. These other health professionals included physiotherapists working in private practice, General Practice nurses who work alongside GPs and nurses who work in rural and remote areas of Australia.

1.2 Thesis outline

The thesis entitled “The development of a validated falls risk assessment for use in clinical practice” is outlined below:

Chapter 1 states the study aims, gives an introduction to the epidemiology of falls in older people and introduces the known risk factors for falls, the consequences of falls and the concept of falls risk assessment.

Chapter 2 includes a brief background about risk factors for falls. This chapter also describes the falls risk assessments that have been used in previous research to assess risk of falling in community-dwelling older people. Lastly, this chapter describes the role that clinicians play in falls prevention.

Chapter 3 outlines the rationale for the study, including a description of the functional tests chosen for possible inclusion in the clinical falls risk assessment and the reasons for their selection. The chapter also includes the methodology, results and discussion of the construct validity study, where performance in the functional tests was compared with the Physiological Profile Assessment measures.

Chapter 4 outlines the methodology, results and discussion of the reliability study.

Chapter 5 presents the methodology, results and discussion of the first external validity study.

Chapter 6 presents the methodology, results and discussion of the second external validity study.

Chapter 7 presents the methodology, results and discussion of the feasibility study.

Chapter 8 summarizes the results of the reliability, validity and feasibility studies and relates the findings to public health in Australia. The strengths and weaknesses of the study design are discussed in this chapter as well as the implications of the study findings for future research and clinical practice.

Chapter Two

Background

2.0 Risk factors for falls

As mentioned in the previous chapter, numerous falls risk factors have been identified [5, 6, 31, 32] and the presence of these risk factors varies from person to person, making a multifactorial risk assessment very important if intervention strategies are to be effectively targeted. Once the risk factors present in the individual are known, appropriate interventions can be implemented to target the deficits identified and reduce the likelihood of future falls. It is particularly important to assess risk factors which are amenable to change. Several falls risk factors are discussed below.

2.1 Sensorimotor and balance factors

Postural control is defined as the maintenance of the body's centre of gravity within its base of support during stance or voluntary movements and in response to postural perturbations [33]. Input to the central nervous system is received from the visual, vestibular and somatosensory systems to allow for adjustments to be made to body sway and posture and therefore maintain an upright body position. Instability and falls in older people can result from impairment in any component of the postural control system [31] and poor balance is widely acknowledged as being a significant contributor to the high rate of falls in people aged 65 years and older [34, 35, 36, 37]. If an older person encounters a hazard that causes them to trip or slip, they will be less likely to recover stability in time to prevent a fall because of age-related impairments in various physiological systems, such as vision [38], peripheral sensation [39], muscle strength [31, 32] reaction time [40] and vestibular sense [41]. Furthermore, when one of the components of the postural control system is deficient, there is a greater reliance on the remaining components to help maintain balance, therefore increasing the likelihood of a fall.

2.2 Medical risk factors

It is evident that there is an association between the use of certain medications and risk of falls, however the strength of this association varies from medication to medication. The strongest level of evidence exists for the relationship between falls and the use of psychotropic medications, with some studies demonstrating a two to three-fold increase in the risk of falling due to their use [6, 9, 42]. In addition, there is a well documented increase in the risk of falls as the overall number of medications taken increases [6, 43]. However, rather than being solely due to the effect of the medications, the associations with falls mentioned above could be due to the poorer health of individuals taking multiple medications and causal associations need to be viewed with caution [27].

The presence of certain chronic medical conditions has also been shown to be associated with an increased risk of falls. These conditions include osteoarthritis [6, 44], depression [5, 45], Parkinson’s disease [6, 32], stroke [6, 46], vestibular disorders [41], visual problems [38], orthostatic hypotension [47], impaired cognition [5, 48], diabetes [39], foot problems [5, 49] and incontinence [5, 50].

2.3 Environmental risk factors

The contribution of environmental factors to falls is difficult to assess, since these factors are not always stable and may be present at some times and not at others, such as poor lighting or trip hazards. Another difficulty with assessing the role of an environmental hazard is that the challenge the hazard poses, depends on the intrinsic impairments present within the individual. Despite these issues, the environmental factors which have been suggested to be associated with falls include poor lighting, faulty or inappropriate footwear, obstructed walkways, loose rugs, spilt liquids, unstable furniture and unsafe stairs [18]. Nevertheless the evidence regarding the association between environmental factors and falls is varied and inconclusive [27].

2.4 Demographic and psychosocial risk factors

A number of other factors not mentioned previously have also widely been found to be associated with falls in the elderly. These include advanced age [32], limitations in activities of daily living (ADLs) [51], female gender [52], living alone [32], fear of falling [53], inactivity [51] and a previous history of falls [4].

So, it is clear from the summary above that falls are a major problem for older people and they result from a variety of intrinsic and situational factors. Some of these factors are relatively simple to measure and impact upon with appropriate interventions and others are difficult to measure and/or to change. The following section will outline the numerous assessment scales and tests that have been used to determine risk of falls in community-dwelling older people.

2.5 Risk factor assessment

The American Geriatrics Society, British Geriatrics Society and the American Academy of Orthopaedic Surgeons Panel on Falls Prevention [54] has published a set of guidelines relating to the prevention of falls in older people. In regard to the assessment of older people as part of routine care, the document states:

1. All older persons who are under the care of a health professional (or their caregivers) should be asked at least once a year about falls.
2. All older persons who report a single fall should be observed as they stand up from a chair without using their arms, walk several paces and return (i.e. the Get Up and Go Test). Those demonstrating no difficulty or unsteadiness need no further assessment.
3. Persons who have difficulty or demonstrate unsteadiness performing the test require further assessment.

Similarly, the Royal Australian College of General Practitioners (RACGP) has published a set of guidelines for preventive activities in general practice [55]. In relation to falls, it states that elderly people should be screened for fall risk factors. These guidelines, while providing a starting point for clinicians to assess their patients for risk of falling, are quite vague and provide little direction for the steps that need to be taken if the screening test does identify an older person who may need an intervention program to reduce their risk of falling. As such clinicians need to be educated about the importance of falls risk assessment which is multidimensional and which is coupled with intervention strategies that are tailored to individual need [56].

Hence, falls may be viewed as a symptom that results from many possible individual causes which vary from person to person and differ in importance depending on the situational factors present at any time. Because of this, risk factor assessment is a logical approach to falls prevention, allowing for the identification of specific causes and hence appropriate intervention strategies [54]. To simply assess the disease processes present within the individual in order to explain their level of falls risk would be inadequate, due to the multifactorial nature of falls risk, the possible disease co-morbidities present and the fact that the relative severity of a disease varies from person to person.

Assessments of mobility and balance are the most commonly carried out physical measures used to predict falls in the elderly. These assessments vary in the time taken to administer them and the number of individual factors assessed, ranging from a single question to measures involving up to 20 items. They also vary in their level of evidence regarding the reliability and validity of the measures obtained and in the feasibility of the measures for use in clinical settings. The following sections describe the large range of falls risk assessments that have been described in the literature, starting with basic questionnaire-type assessments through to comprehensive multifactorial assessments. The advantages and disadvantages of these assessments for use in clinical settings are also discussed and a summary of these points is included in Table 2.1.

Single question/ questionnaire falls risk assessments

The quickest and simplest way to determine if a person is at risk of falling in the future is to simply ask them if they have had any falls in the previous year, since the occurrence of previous falls is a well documented risk factor for future falls [4, 57]. This is a question which is used in isolation to assess risk of falling as well as part of more detailed assessments with many factors [50, 58, 59]. The downside of using this single question to assess risk is that while it may indicate if a person is likely to fall in the future, it does not give an indication of what particular factors are contributing to that risk, nor does it identify people who may be at risk but who have not yet had a fall. Hence, a further more comprehensive risk assessment is needed to identify which factors are placing the individual at risk so that appropriate intervention strategies can be tailored to need.

The Falls Efficacy Scale (FES) [60] is a more comprehensive questionnaire that is used to assess fear of falling and has also been used to predict risk of falls. The FES is a 10 item self-administered questionnaire which evaluates the individual's confidence in their ability to avoid a fall during activities of daily living. Respondents rate their confidence in performing each activity without falling on a 10 point scale, with 1 indicating extreme confidence and 10 indicating no confidence at all. The test-retest reliability of the scale is good (Pearson's r=0.71) when assessed in a sample of 18 older people [60]. In a study involving 60 men and women aged 65 years and older, the FES score significantly correlated with scores on the Berg Balance Scale, but there was no significant association between retrospective falls and the FES score [61], leading the authors to conclude that the FES is a clinical indicator of balance but not falls risk in older people. This result is in contrast to the findings of Tromp and colleagues [50] however, who found that the FES score was one of several factors associated with falls in a prospective one-year follow-up of 1285 people aged 65 years and over. The scoring method for the FES was simplified slightly in this study, so that each item was rated on a 3 point scale, where 0 equalled "no confidence" and 3 equalled "completely confident" and hence the highest possible total score was 30. An odds ratio (OR) of 1.8

(95%CI= 1.3-2.3) was found for the prediction of one or more falls in the follow-up year and an OR of 2.0 (95%CI= 1.4-2.8) was the result for the prediction of 2 or more falls. Since this study involved a large sample of older people and falls were measured prospectively for a period of one year, the results would appear to be more dependable than those of the other studies mentioned which relate to the FES.

Another measure of balance confidence in older people when carrying out activities of daily living is the Activities-specific Balance Confidence (ABC) scale [62], which involves a 16-item self administered questionnaire. The questionnaire items ask the subject to rate their confidence levels when asked to complete a number of everyday activities, which are mainly gait-related and transfer items, such as walking outside and up and down stairs, reaching up high and getting in and out of a car. Each item is rated on a scale from 0% (no confidence) to 100% (complete confidence) and the total score is the average of these 16 sub-scores. The reliability of the total ABC score has been reported to be good ($r=0.92$, $p<0.001$) when tested on two occasions in a study involving 21 older subjects [62]. In this study, however, while participants who had fallen in the previous year had lower scores on the ABC compared to their non-falling peers, the difference between the groups was not statistically significant, which may be explained by the small sample size.

Another study conducted by Hotchkiss and colleagues [63] examined the ability of both the FES and the ABC scale to discriminate fallers from non-fallers in a larger sample of people aged 60 years and over (n=118). Falls were measured retrospectively and the results showed that both scales could not correctly classify people as fallers and non-fallers in this group.

Single risk factor assessments which require minimal or no equipment

The ability to stand on one leg is a very simple measure of balance that has been used previously as a solitary measure of falls risk as well as being part of several balance assessment tools [64, 65]. The test has been reported to have good inter-rater reliability (ICC=0.75) when assessed with a small group of healthy older people [66]. The association between single-leg stance balance ability and falls was assessed by Vellas et al [67] in a group of 316 community-dwelling people over the age of 60. The assessment protocol measured whether or not the subjects could stand on one leg for a period of five seconds. After three years of prospectively monitoring falls, it was found that impaired one-leg balance was a significant independent predictor of injurious falls but not of all falls. The researchers concluded that no single factor could be relied upon as a sole predictor of fall risk or injury due to the diverse causes of falls.

Similarly, one-legged stance was one of the tasks assessed in a study involving community-dwelling men and women aged 60 years and over, conducted by Nevitt et al [32], which found that an inability to stand in this position for more than two seconds was associated with a significantly increased risk of multiple falls. The samples in both of these studies however, exhibited a higher rate of falling than is commonly found in community-dwelling samples of this age group. The subjects in the Nevitt et al study were selected because they had suffered a fall in the previous year and 57% of them went on to experience at least one fall during the study period. Similarly, 71% of the subjects in the Vellas et al study fell during the 3 year follow-up period. It may follow, then that this test is more predictive of falls in high risk groups and its validity for predicting falls in samples of people at lower risk of falling is less reliable.

A study which supports this idea is one which was conducted by Maki and colleagues [37]. The test of single leg stance was included in this prospective follow-up study with 100 community-dwelling older people aged 62 years and over. The results of the study showed that when the test was conducted with eyes open, performance did not discriminate between fallers and non-fallers (p=0.62), however when the eyes were closed there was a significant difference between groups (p=0.02), showing that a more challenging protocol of this test may be needed to predict falls in healthy, community-dwelling people. Similarly, a one-legged stance test was included in a large prospective study which examined risk factors for falls in 984 older women [3]. The test involved measurements of the time until balance was lost while standing in four conditions- on right and left foot with eyes open and then closed. People who scored less than five seconds in the tests were considered to have failed and the scores from the four conditions were summed to give an overall score. When the results were evaluated with a logistic regression analysis, failure in this test of balance was one of nine significant independent predictors of future falls, yielding an odds ratio of 2.0 (95%CI= 1.3-3.0).

A similar test to the one-legged stance test is the Romberg test, which was developed by German neurologist Moritz Heinrich Romberg in 1846. The test requires the subject to stand with feet together and eyes closed for a fixed test period (usually one minute). This is a test of balance which has been associated with risk of falling in older people [58]. In the Stalenhoef et al study, performance in the Romberg test was compared between 46 community-dwelling people who were multiple fallers and 192 community-dwelling people who were non-fallers, where falls were measured prospectively for a period of nine months The results showed that an inability to perform the Romberg test, resulted in an odds ratio of 3.7 (95% CI= 1.8-7.8) for the prediction of recurrent falls. Despite this significant result, when grouped with numerous other falls risk measures, the Romberg test was not one of the four best predictors of recurrent falls which were selected for inclusion in a risk model to be used in clinical practice, which were abnormal postural sway, a history of two or more falls in the previous year, poor handgrip strength and depression.

Sit to stand (STS) ability is a simple functional task that is a predictor of disability [68, 69] and falls risk [32, 70] in older people. It is commonly used to assess lower limb strength and balance and performance in the task has also been found to be associated with other sensorimotor and health factors in older people [71, 72]. It is a task which is included in several multifactorial balance and mobility assessments including the Performance Oriented Mobility Assessment [64], the Berg Balance Scale [73], the Timed Up and Go Test [74] and the Elderly Mobility Scale [75]. Its procedure has several variations ranging from a timed task with one, three, five or ten repetitions to counting the number of repetitions performed in a set time [72, 76, 77]. Detailed analysis of the five repetition STS test as a predictor of balance dysfunction has been carried out by Whitney et al [78] who found that a performance time of 14.2 seconds was the optimal cut-off point which achieved the best sensitivity (61%) and specificity (59%) in people over 60 years of age. Similarly, performance in the sit to stand test with one repetition has been found to be a significant independent predictor of multiple falls in a study involving 325 community-dwelling people aged 60 years and over [32]. In this study, a performance cut-point of ≥2 seconds to stand up once was associated with a significant relative risk score of 2.4 (95% CI= 1.8-3.2). Other studies that have also found an association between performance in a sit to stand test and risk of falling include studies by

Delbaere et al [79], which included prospectively measured fall rates and Tromp et al [50] who found that slow performance in the five repetition test was associated with an OR of 1.4 (95%CI= 1.2-1.6) for the prediction of recurrent fallers in a large study in which falls were also measured prospectively. The reliability of the STS test was assessed by Sherrington and colleagues [80] in a sample of post-hip fracture patients, where it was found to have an ICC score of 0.92 (95% CI=0.84-0.97).

Since many falls occur during locomotion, it seems logical that an assessment of falls risk would include some measure of gait. One of the simplest ways to assess gait which has been used extensively in the past is to simply measure the time taken to walk a set distance, often 6 or 10 metres. A study by Piotrowski and Cole [61] examined the validity of several tests to measure balance and predict falls in 60 men and women aged 65 years and over. They found that performance on the self-paced walking test over a distance of 10 metres significantly discriminated between people who had fallen in the previous year and non-fallers and that the fallers displayed reduced gait speed and step length, resulting in a more cautious gait pattern. A more recent study with a similar sized sample of older community-dwelling people [81] also found that a timed walk over a distance of 50 feet (15.2 metres) was one of two tests (the other being a timed floor transfer) that together correctly classified prospectively followed-up fallers and non-fallers with an accuracy of 95%. These two results are supported by the work of other authors who have found that fallers walk more slowly than non-fallers [32, 82, 83] and also display changes to several gait parameters [8, 84]. The test-retest reliability of a similar gait test, self-paced walking over a distance of six metres, has previously been examined [85] and was found to be good (ICC=0.74, 95%CI = 0.52 – 0.87) in a group of older community-dwelling people.

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The Functional Reach Test (FRT) is a commonly used measure of dynamic balance control [86] which requires the subject to reach forward as far as possible with the arm at 90 degrees of shoulder flexion and the feet fixed in position. The test has demonstrated high test-retest reliability (r=0.92) when assessed with a sample of young and older people [86] and in a large sample of cognitively impaired and unimpaired older people [87]. Performance in this test declines with age and has demonstrated some ability to predict falls in older men [88] and in a small sample of community-dwelling men and women [89]. However, a more recent study compared performance in the FRT by healthy elderly people and people with diagnosed balance impairment [90]. The results showed no significant difference in FRT distance between the two groups, leading the authors to conclude that FRT does not measure dynamic balance. These results are also supported by the work of Brauer and colleagues [91] who found that performance in the FRT by 100 community-dwelling older women did not predict faller status after 6 months of prospective falls data collection. One criticism of the FRT as a measure of falls risk is that because it is done with a bilateral stance, it may not identify people who have problems with balance during locomotion related activities which necessitate one-legged stance [92], especially since many falls occur during locomotion. Other authors have suggested that the FRT is difficult to standardise and perform in home environments because of the different circumstances faced, such as different floor coverings, limited space and difficulties with attaching tape to the wall for measurement of the test [58]. In addition, the safety of the test for assessing people who may be at risk of falls was questioned by these authors.

Another reaching test is the Lateral Reach Test (LRT) [93] which is a measure of medio-lateral postural stability. In this test, the person being assessed stands with their back to a wall and is directed to reach directly sideways with one arm as far as possible, without overbalancing, taking a step or touching the wall. The test has good reliability (ICC= 0.99) and is significantly correlated with other laboratory-based measures of reach. However, in a study involving 100 elderly community-dwelling women [91], performance in the test did not vary in people who had no falls, one fall or multiple falls, as measured prospectively over a period of six months. This result led the authors to suggest that the lateral reach test may not have been challenging enough for the highly functioning and independent subjects included in this study and hence was not able to distinguish between fallers and non-fallers.

A somewhat more challenging test than the reaching tests mentioned above is the Step Test (ST) which was developed by Hill and colleagues [92] as a measure of dynamic single limb stance and rapid stepping. The test involves the subject placing one foot onto a low step (7.5cm high) positioned in front of them, then returning the foot to the floor and then repeating this procedure as fast as possible for the duration of the test (15 seconds). The supporting foot is not allowed to be moved during the test and the final score is the number of completed foot steps within the test time period. The test is then repeated for the other foot. The ST has high reliability, in both a small sample of 14 healthy older people (ICC>0.90), a group of 21 older stroke patients (ICC>0.88) [92] and in 30 older people who had recently suffered a hip fracture (ICC=0.94) [80]. Performance in the test is significantly correlated with performance in the Functional Reach Test (FRT) and with gait velocity and stride length. The tests ability to predict faller status however has not been confirmed and in fact in one study [91] performance in the ST was found to be similar in a group of elderly fallers compared to non-fallers, leading the authors to conclude that more work in the development of clinical balance tests needs to be undertaken. An additional study has found a performance cut-point of less than 11 steps in the ST to be a significant discriminator between multiple fallers and non-multiple fallers in a small sample of older people, with a resultant sensitivity of 81% and specificity of 63% [89]. These results however need to be viewed with caution since falls were measured retrospectively and only for a period of 6 months.

Another test which involves rapid stepping and obstacle avoidance is the Four Square Step Test (FSST) [89]. The test is a measure of dynamic balance and requires the person being tested to step four times in one direction with steps that are 80% of the length of their maximal step length. The subject must rapidly change direction while stepping forwards, backward and sideways over a low obstacle and the time to complete the test is measured. The FSST is highly reliable; ICC=0.99 for inter-rater reliability as assessed with 30 community-dwelling older people and ICC=0.98 for retest reliability as assessed with 20 community-dwelling older people. The test displays significant correlations with the Timed Up and Go (TUG) test ($r=0.88$, $p<0.001$) and the Step Test ($r=-0.83$, $p<0.001$) and in a study involving 81 community-dwelling older people, performance in the test was found to vary significantly between multiple fallers and non-multiple fallers. It was found that when the performance cut-off was set at 15 seconds, the test had 89% sensitivity and 85% specificity for predicting multiple falls, however since falls were measured retrospectively and only for the previous 6 months, these results may not be definitive. The authors promote the FSST as easy to score, quick to administer and requiring no special equipment and only a small amount of space. However it is not appropriate for cognitively impaired elderly people because of the complex stepping sequence involved.

Performance in two other measures of stepping, maximal step length (MSL) and the rapid step test (RST) has been found to be slower in older adults compared with young people and also in balance impaired older people compared with their unimpaired peers [94]. MSL is the maximum distance that a person can step out to and still be able to return to upright stance and is conducted in each direction with each leg. The RST is the time needed to take 24 steps of near-MSL length in various directions. The 24 steps include 4 steps to the front, back and side with the left and right leg in a random order. Both tests have good test-retest reliability, with $r>0.70$ for all analyses. A study was conducted which compared performance in these tests by 12 young women and 22 older women who were categorised as impaired (n=10) or unimpaired (n=12) depending on whether they had suffered more than one fall in the previous year or not. The results showed significant differences in the performances of both the MSL test and the RST between the young and old age groups and between the impaired older group and the unimpaired older group ($p<0.0001$ for MSL test and $p<0.01$ for RST comparison). Performance in the MSL test and RST was also compared with standard tests of gait, mobility, balance and functional impairment in the older adults, where the MSL test was found to be a good predictor of mobility, self-reported function and balance confidence [94]. These results led the authors to conclude that stepping performance could be used in future studies to predict falls and fall-related injuries. A more recent study investigated the reliability and validity of the MSL test and RST for predicting falls in a sample of 167 mildly balance impaired older people who had been recruited for a fall-reduction and balance-training program [95]. In this study, subjects were classified as frequent fallers (2 or more falls) or non-frequent fallers based on the number of falls experienced in the preceding 12 months. The results showed that performance in the MSL test was strongly associated with the risk of being a frequent faller (OR=0.53, 95%CI=0.32-0.84), however the association between scores in the RST and falls was not significant. Furthermore, the reliability of the mean MSL test score, as assessed in a sub-set of 62 subjects was high (ICC=0.86, p<0.001), with a lower reliability coefficient found for the AST (ICC=0.42, p<0.001). Additionally, since the scores for the six directions of stepping in the MSL test were highly correlated (r=0.88-0.96, p<0.001), the authors concluded that testing of all the six leg-directions may be unnecessary and a one direction test may be just as valid and substantially quicker to carry out. While these two studies provide some evidence of the ability of the RST and MSL test to distinguish between recurrent fallers and non-recurrent fallers, the measurement of falls in both of these studies was conducted retrospectively which, as has been mentioned before in this chapter, has limited accuracy and which means that further investigation of the usefulness of these tests as predictors of future falls is needed.

Functional falls risk assessments

The inability to get up off the floor following a fall is a measure of weakness and social isolation which has serious post-fall health-related consequences [32, 96]. A functional task that has been utilised by a number of authors to assess this problem and its association with risk of falling is the timed floor transfer test [81, 97]. This test is a measure of strength, flexibility, function and problem solving which involves timing how long it takes a person to move from a standing position to sitting on the floor and then back to the standing position. In a study by Murphy et al [81] the test-retest reliability of the task was found to be moderately high ($ICC_{2,1}$= 0.79, p=0.0001) when assessed with 13 older men and women. When the task was recoded to be a dichotomously scored test (unable or able to perform the test), the results showed that the test had sensitivity and specificity values of 64% and 100% respectively.

Additionally, out of nine possible tests included in a discriminant function analysis to determine the best predictors of fall status, the floor transfer task was one of two tests (the other test being a timed walk) included in the final model which displayed a predictive accuracy of 95%. This result is encouraging but further research needs to be conducted with this test, since the sample size included in this study was small, in order to fully document the timed floor transfer tests ability to predict falls in older people. The reliability of the test should also be investigated.

The Physical Performance Test (PPT) [98] is another scale which assesses functional abilities, with seven of its nine items assessing balance. The balance tasks included in the PPT are: lifting a book and putting it on a shelf, putting on and taking off a jacket, picking up a coin, turning 360 degrees, walking 50 feet and negotiating stairs (2 items). The other two items relate to eating and writing ability. Most tasks are timed and all are assessed on a scale from 0 to 4 (“unable to do” to “the fastest”, respectively) and the test is reported to take 10 minutes to complete. A study by VanSwearingen [99] examined the ability of the PPT to determine fall status in a sample of 84 older community-dwelling men, where falls were measured retrospectively. The results showed that a score of 15 or less on the PPT predicted recurrent falls with a sensitivity of 79% and a specificity of 71%. These results, however relied on the retrospective recall of falls which may not be completely accurate, as has been found previously [100].

Delbaere and colleagues [79] assessed the predictive ability of the PPT in a sample of 263 older subjects with 12 months of prospective falls surveillance. The researchers found a score of less than 25 in the PPT to be a good predictor of future falls (OR=4.16, p<0.001). Although the PPT is quick and easy to score and measures balance in a variety of everyday situations, it has the disadvantage of requiring more equipment to perform than most of the other assessments mentioned here. Additionally, because the PPT includes a measure of writing ability, people who have poor literacy skills may be disadvantaged when being assessed with this test.

The Berg Balance Scale (BBS) is a performance-based measure of balance consisting of 14 observable tasks, ranging from simple tasks such as maintaining stability while standing to more dynamic tasks such as positional transfers, bending, reaching and turning. It takes approximately 15 to 20 minutes to administer and each task is scored on a five-point scale. It has high intra-rater and inter-rater reliability, with ICC values found to be greater than 0.95 in both evaluations, which involved nursing home residents and people who had suffered a stroke [101]. Another study carried out by the authors of the BBS involving 113 residents of an aged care hostel, found a total score of below 45 (out of a possible score of 56) to indicate a relative risk of 2.7 (95%CI=1.5-4.9) for multiple falls, measured prospectively over the following 12 months [73].

A more recent study conducted by Lajoie and colleagues [102] determined that a cut-off score of 46 was able to predict a history of falling in 125 community-dwelling and nursing home residents with a sensitivity of 82.5% and a specificity of 93%. Similarly, a study by Thorbahn and Newton [103] examined the validity of the BBS in sixty-six retirement village residents who were aged 69 to 94 years. The results showed that performance on the test, as determined by a cut-off score of 45 was able to discriminate between fallers and non-fallers (as measured prospectively over a period of six months) with fair sensitivity (53%) and high specificity (92%). The assessment was also found to have high inter-rater reliability (r=0.88).

More recently, a case-control study involving 78 community-dwelling people was conducted where falls were measured during the six months prior to the trial [104]. The authors compared performance on four commonly used functional mobility and balance tests and found the BBS to be the most accurate test for distinguishing between fallers and non-fallers. A BBS score of 47 was found to be the most accurate for discriminating between fallers and non-fallers (sensitivity =88%, specificity =77%), a score of 38 was the most accurate for the multiple faller versus non-faller comparison (sensitivity =96%, specificity =96%) and a score of 33 was the most accurate for the multiple faller versus single faller comparison (sensitivity =94%, specificity =91%). In addition to these findings, the authors identified three of the individual BBS tasks as being the significant predictors of falls; these were the pick up an object from the floor item, the stand on one leg item and the place alternate feet on a stool item. The authors suggested that these items should be considered for inclusion a fall risk index for future evaluation.

In contrast to these findings, a study conducted by Boulgarides et al [105] with 99 active and independent community-dwelling older people who were followed up for the occurrence of falls over a period of 12 months, found that scores on the BBS did not predict falls. This result led the authors to conclude that the BBS was not appropriate for detecting falls risk in highly functioning, active and independent older people, which is a view supported by other researchers [103]. Since much of the research published regarding the BBS either involves the testing of frail older people and/or includes retrospective measurement of falls, more work is needed to determine the applicability of this assessment for predicting future falls in active, community-dwelling older people.

Another test that is correlated with the Berg Balance Scale is the Timed Up and Go (TUG) test [74]. It is an adaptation of the Get-Up and Go Test (GUGT) [106] and is a measure of the time taken for a subject to stand up from a seated position, walk a distance of three metres, turn, walk back to the chair and sit down. It takes one or two minutes to carry out and has high inter-rater and intra-rater reliability (ICC=0.99 for both measures) when tested with 60 frail and 10 healthy older people [74]. However poor reliability of the TUG was found in another study [87] which examined the test results of a large sample of 1115 cognitively impaired and unimpaired older people. This study also found that the TUG was not feasible for many cognitively impaired people to undertake. The predictive validity of the test has also not been fully established, since many of the studies that have examined this have utilised retrospective falls data which cannot be relied upon fully. One such study was conducted by Gunter et al [107] and involved 157 men and women who were classified as non-fallers, fallers or multiple fallers using falls data from the previous 12 months. The results showed that performance in the (GUGT) was able to correctly classify people who were fallers with an accuracy of 98%, but it was less accurate for classifying non-fallers (15% accuracy).

In accordance with this research, a study by Rose and colleagues [108] classified 134 community-dwelling older subjects as either non-fallers or multiple fallers using retrospective data. They found that with a cut-point of 10 seconds for discriminating between non-fallers and recurrent fallers, the overall specificity was 86% and sensitivity was 71%. Similarly, in a case-control study with 15 multiple fallers and 15 non-fallers a TUG cut-point of 14 seconds significantly discriminated between the two groups [109] with a resultant sensitivity and specificity for falls status of 87%.

Yet another case-control study involved 27 multiple fallers and 27 non-multiple fallers, which were classified with the use of retrospective falls data from the previous 6 months [89] was conducted with community-dwelling people aged over 65 years The results also showed a significant difference in test performance between the two groups and the optimal performance cut-point was 13 seconds which resulted in 89% sensitivity and 67% specificity. Another case-control study conducted by Chiu and colleagues [104] involving 78 community-dwelling people found the TUG to have high sensitivity and specificity for discriminating between single fallers and multiple fallers (88% and 82% respectively) but only moderate sensitivity and high specificity for discriminating between single fallers and non-fallers (59% and 88% respectively).

This contrasts with the findings of Boulgarides et al [105] who concluded that the TUG did not predict prospectively measured falls in an independent and active sample of 99 community-dwelling older people. From this summary, it is apparent that the research which has shown performance in the TUG to discriminate between fall groups has consisted of retrospectively measured falls data taken from relatively small samples of subjects, making these results less than definitive as far as the true ability of this test to predict future falls is concerned. Additionally, many of these studies have compared subjects who have experienced multiple falls with people who have not fallen, thereby overestimating the predictive ability of the TUG test in the general population where people who experience multiple falls are less common than one-time fallers.

Another functional balance and mobility assessment is the Elderly Mobility Scale was developed by Smith [75] and includes the assessment of seven functional activities including lying to sitting, sitting to lying, sit to stand, stand and reach, gait (need for assistance to walk), timed 6 metre walk and functional reach. Each item is scored on a scale from 0 to 2 or 3, with 0 indicating impairment and 2 or 3 indicating independence. The maximum possible score is 20. It has good inter-rater reliability (result from Mann Whitney test was 196, p=0.75), which was assessed with 15 older hospitalised patients. It also has good concurrent validity, which was tested with 36 hospital patients and out-patients and compared with scores on two other physical measures of function: the Barthel Index [110], where the correlation with the EMS was 0.96 and the functional independence measure (FIM) [111], where the correlation with the EMS was 0.95, however its ability to predict falls was not assessed in this study.

The EMS was included in a case-control study conducted by Chiu et al [104] involving 78 community-dwelling older people which found that it discriminated between multiple fallers and non-fallers, where a cut-off score of 19 yielded 91% sensitivity and 96% specificity. A performance cut-point of 15 also discriminated between multiple fallers and single fallers (sensitivity=88%, specificity=91%). However, since performance in the EMS did not accurately discriminate between single fallers and non-fallers, the authors concluded that the tasks included in the EMS may not be strenuous enough to challenge the balance of people who have single falls and that further validation of the EMS for falls risk screening is necessary.

A further study involving the EMS was carried out in a hospital setting with 76 geriatric day hospital patients with identified mobility problems, who were aged over 60 years [112]. The patients were assessed with the EMS prior to discharge and falls were monitored for the next four months. The results showed that performance in the EMS did predict people who suffered multiple falls during the follow-up period (p=0.008) but did not predict single fallers. Both of the studies summarised here which have evaluated the ability of the EMS to predict falls in older people have had small sample sizes, one included the retrospective measurement of falls and the other, while measuring falls prospectively, only included four months of follow-up and involved the assessment of frail older people prior to hospital discharge, hence the conclusion that the EMS is a validated measure of falls risk suitable for use with community-dwelling people can not be made at this stage.

Similar to the Berg Balance Scale is the Performance Oriented Mobility Assessment (POMA), which was developed by Tinetti [64]. It involves the assessment of several functional tasks which are used during normal daily activities and includes a balance subscale and a gait subscale. The balance subscale has thirteen items which involve the maintenance of balance during certain postures and changes of position, such as standing up from a seated position without the use of arms for support, standing balance, balance with eyes closed, one-legged standing balance and turning balance. Some of these items are scored dichotomously (able/ unable to perform) and others are scored 0, 1, 2 to reflect the quality of the performance with a possible total score range of 0 to 24. The gait subscale evaluates nine tasks, including such things as step height, length and symmetry, trunk stability and turning while walking and has a total possible score of 16, which give an overall total possible mobility score of 40.

The POMA has good inter-rater reliability, which was demonstrated in a study where a physician and a nurse scored performance simultaneously and agreed on 85% of the items, with a resultant total score that differed by less than 10% [64]. The original authors of the tool have also established its validity in predicting future falls in a study of 336 community-dwelling people aged 75 years and older [5]. In this study four of the balance items from the POMA (unsteady sitting down, unable to single-leg stand unsupported, unsteady when turning and unsteady after gentle push on sternum) and three items from the gait subscale (increased trunk sway, unable to pick up walking pace and increased path deviation), when combined, were able to predict falls. The presence of between three and five of these risk factors resulted in a RR score of 1.7 (95% CI= 1.1-2.7) for future falls and the presence of between six and seven of these risk factors resulted in a RR score of 1.7 (95% CI= 1.1-2.7) for future falls. The authors combined these results with other measures of falls risk, to devise a multifactorial falls risk assessment. The final model included the following factors in addition to POMA variables: use of sedatives, cognitive impairment (five or more errors on the Short Portable Mental Status Questionnaire), lower-extremity disability (any reported problems with strength, sensation or balance), palmomental reflex and foot problems (moderate or severe bunions, toe deformities, ulcers or deformed nails). The risk of falling increased linearly as the number of risk factors present from this model increased, from 8% with no risk factors, to 32% with two risk factors and 78% in people who displayed four or more risk factors.

Performance in the balance subscale of the POMA (B-POMA) has been compared between community-dwelling people who had single falls (n=17), multiple falls (n=22) and those who had not fallen (n=39) [104], as categorised with the use of retrospective falls data from the previous six months. The results showed that performance in the B-POMA varied significantly between single fallers and non fallers (p=0.04) and multiple fallers and both single fallers and non fallers (p=0.001). In addition, the sensitivity and specificity for the single faller/ non faller comparison at the cut-point of 21 were 82% and 65% respectively, for the multiple faller/ single faller comparison at the cut-point of 17 the values were 82% and 100% respectively and for the multiple faller/ non faller comparison at the cut-point of 17 the values were 96% and 96% respectively, showing that the B-POMA was an accurate predictor of faller status. The advantage of the POMA as a measure of falls risk is that it is easy to administer, straightforward for the subject to understand and only takes a short amount of time to carry out. The disadvantage of this assessment is that it may not be suitable for use with community-dwelling elderly people who are still quite active and mobile due to the low intensity and basic nature of its components. In addition, since the components of the POMA are scored either dichotomously or on a three point grading scale, it has been suggested [113] that this makes it difficult to detect small differences in ability, which reduces its utility as a measure of change in performance, for example as the result of an intervention program.

While it is clear that many of the assessments described above are valid and reliable falls risk factor measures, it is also apparent that if these assessments are used in isolation, the information gained is limited to one or two particular risk factors and other important factors such as vision, peripheral sensation, medical factors and fall history are not explored. This may lead to a belief that if the individual being tested passes the assessment, that they are not at risk of falling even though there may be other factors contributing to their risk which have been left unevaluated. That is why a multifactorial risk assessment gives a more accurate picture of an individual's risk of falling.

Multifactorial falls risk assessments

The Fast Evaluation of Mobility, Balance and Fear (FEMBAF) assessment tool is a comprehensive assessment which was developed by Arroyo and colleagues [114] and consists of three components: firstly, an assessment of 22 risk factors for falls ranging from limitations in activities of daily living (ADL) and fear of falling to history of falls, secondly, an evaluation of the subject's ability to complete 18 functional tasks and thirdly, reports of fear, pain, mobility difficulty and self-perception of strength in each of 18 performance oriented tasks. The tasks are rated on a three-point scale, where a score of 1=unable to perform or initiate the task, 2= task initiated but unsteady or partially completed and 3= task successfully completed without imbalance and the maximum total score possible is 54. The authors of the assessment conducted a case-control study to evaluate the association between performance in the assessment and risk of falling [114]. This study involved 241 older community-dwelling people, 59% of whom had experienced at least one fall in the previous year. The results of the study showed that people who scored between 35 and 45 were categorised as at moderate risk for falls and people who scored less than 35 were categorised as at severe risk for falls.

In another study involving 35 community-dwelling people aged 60 years and over, Di Fabio and Seay [115] evaluated the reliability of the FEMBAF and its validity in relation to other functional tests of mobility and balance which have been associated with risk of falling. Their results showed that several of the components of the FEMBAF were significantly correlated with performance in the Clinical Test of Sensory Interaction on Balance (CTSIB) (Spearman $r=0.5-0.6$, $p<0.05$), in the balance subscale of the POMA (B-POMA) (Spearman $r=0.6-0.9$, $p<0.05$) and in the TUG (Spearman $r=0.4-0.6$, $p<0.05$). The FEMBAF was also found to have high inter-rater reliability (Kappa=0.95), but test-retest reliability was not assessed. The predictive accuracy of the FEMBAF however has not been studied, making its use as a clinical assessment of falls risk yet to be determined.

The Elderly Falls Screening Tool (EFST) is an assessment which consists of five items: self-reported falls, injuries associated with falls, frequency of near falls, slow walking speed (<30m/ min) and observed gait abnormalities [59]. In a prospective study involving 283 community dwellers, an increased risk of falling was indicated by the presence of two or more of these risk factors, with a sensitivity of 83% and specificity of 69%. One of the problems with using the EFST to identify people at risk of falling in clinical settings is that the estimated assessment time of 17 minutes may be too time consuming for many settings, as well as the fact that the reliability of the assessment has not been established.

Tromp and colleagues [50] conducted a one year prospective study which aimed to develop a fall-risk model for predicting falls in 1285 community-dwelling people aged 55-85 years. At initial assessment, many potential risk factors were measured ranging from socio-demographic factors, chronic diseases, impairments in physical functioning, low levels of activity and mobility, physical performance measures, previous falls and fear of falling. After the 12 month follow-up period the factors which were found to be significantly and independently associated with falls were previous falls, urinary incontinence, visual impairment (as measured by asking the subject if they could recognise a person’s face at a distance of four metres) and the use of benzodiazepines, with odds ratios ranging from 1.6 to 2.5. The significant independent predictors of multiple falls were previous falls, urinary incontinence, visual impairment and functional limitations (reported difficulties with at least two of the following activities: climbing stairs, using own or public transportation or cutting his or her toenails) with odds ratios ranging from 1.7 to 2.7. A scoring system for the Fall-risk Screening Test was also developed which used the regression coefficients of each of the predictors in the models to weight each factor in relation to its relative importance, which resulted in a range of possible scores from 0 (no risk factors) to 15 (all four risk factors). This scoring system was then used to determine the optimal score which produced the highest sensitivity and specificity for the prediction of multiple falls. This optimal level was determined to be a score of 7, which resulted in a sensitivity of 54% and specificity of 79%. The positive predictive value at this score was 25% and the negative predictive value was 93%, meaning that 25% of the subjects with a score of 7 or more are correctly identified as multiple fallers and conversely 93% of the subjects with a score of less than 7 are correctly identified as non-multiple fallers. The authors concluded that the Fall-risk Screening Test was quick and easy to use and predictive of recurrent falls, however because of its low predictive value, further validation is required before it is implemented as a screening tool in clinical practice.

Similar results were obtained in a study which involved 311 community-dwelling people who were aged 70 years and over, which was carried out by Stalenhoef et al [58]. The aim of the study was to develop a risk model for predicting recurrent falls, which would be relevant for use in a general practice setting. After measuring many possible predictors of falls ranging from psychological and physiological factors to a mobility and home-safety assessment, the results showed that the significant independent predictors of people who suffered recurrent falls when compared to non-fallers were abnormal postural sway (as measured by the Postural Sway Test [37), reduced handgrip strength (≤22kg for men and ≤12kg for women), depression (score of ≥22 in the depression subscale of the Symptom Checklist (SCL90) [116]) and a history of two or more falls in the previous year, with odds ratios ranging from 2.2 to 3.9. Like the model developed by Tromp et al [50], summarised above, the authors of this risk assessment also developed a scoring system to allow for the categorisation of people as being at low, moderate or high risk for future falls. Low risk is defined as the presence of 0-1 predictor, moderate risk is the presence of 2 predictors and high risk is the presence of 3 or more predictors. In addition, the individual risk factors were given weighted scores depending on the results of the multiple regression analyses, which resulted in a range of possible total scores from 0 to 23 points. The authors concluded that the risk assessment is a quick and easy way to identify older people at risk of falls in a clinical setting, however they recommended that further validation of the assessment and measurement of its feasibility in this setting needs to be carried out. This seems warranted since some of the measures included in the assessment require specialised equipment and are time consuming to assess, which may present a barrier to its use with busy clinicians.

A comprehensive and validated falls risk assessment is the Physiological Profile Assessment (PPA) [117], which provides direct and reliable measures of the sensorimotor factors that play important roles in the control of postural stability while standing and walking. It was developed for use with community-dwelling older people and comprises tests of vision, peripheral sensation, lower limb strength, simple reaction time, postural sway and dynamic balance. There are two versions of the assessment- a long version which comprises 16 tests and takes approximately 45 minutes to administer and a short version which comprises 5 tests and takes approximately 15 minutes to administer. The PPA tests take into account both "normal" age-related functional declines and any additional impairments resulting from medical conditions (whether diagnosed or not). In multivariate models, weighted contributions from five of these variables, the edge contrast sensitivity test, the proprioception test, the knee extension strength test, the hand reaction time test and the postural sway test provide a falls risk score that can predict those at risk of falling with at least 75% accuracy in community settings [31, 48]. The short version of the PPA is quick to administer and the five tests are scored continuously, making them sensitive to change over time and therefore they are able to be used to monitor the progress of intervention programs or to measure decline in function over time. The individual tests have good reliability [117] and the test administration can be learnt with a minimum of training by a variety of people with different professional backgrounds.

An additional benefit of the PPA is that the results of the assessment prompt a summary report which not only outlines how the individual performed in the assessment when compared to age and sex-matched normative data, but it also includes recommendations for interventions to address any risk factors identified. This is a definite advantage that the PPA has over the other falls risk assessments mentioned here, since the goal of any falls risk assessment should not only be to identify who is at risk of falling and which factors contribute to that risk, but to instigate strategies to reduce the risk of falls.

Despite its ability to accurately predict falls, its multifactorial nature and its ability to guide intervention strategies and evaluate their performance over time, there are barriers to the use of the PPA as a standard assessment of falls risk in many clinical settings. Firstly, the PPA requires the use of specialised equipment and the data obtained requires computer processing, which result in a more costly and less portable assessment than many of those summarised here. In addition, the PPA is more time consuming to administer and score than many other assessments and its use does require some training on the part of the assessor.

From these summaries, it is clear that much work has been done in the past to identify specific fall risk factors and develop appropriate assessment scales for measuring these risk factors in community-dwelling populations. Many of the assessment scales developed previously include the assessment of several risk factors, some of which can be modified with interventions, however most of these assessment scales have not been included as a routine assessment by general practitioners and other health professionals. The reason for this may be that existing fall risk factor assessments take too long to administer, require cumbersome equipment and/or do not include guidance for the initiation of intervention strategies for identified risk factors. It may also be because some of the assessment scales described lack validity and have no proven feasibility in a clinical setting. It was this lack of a "gold standard" multifactorial risk assessment tool for use in a clinical setting that led to this study being carried out. This study aimed to use the PPA model as a foundation for the development of a clinical falls risk assessment. The philosophy employed here was to try to incorporate the strengths of the PPA (validity for predicting falls, reliable measures which are physiological rather than disease oriented, recommendations for intervention strategies) into an assessment which would be appropriate for use in busy clinical settings. Before doing so, it was important to investigate the role that clinicians play in falls prevention, the details of which are outlined in the next section.

Table 2.1: Falls risk assessment measures used in previous research.

Assessment	Author, date	Population *	Items	Validity	Reliability	Prospective followup	Time **	Equipment needed
Previous falls	Vellas et al, 1997	316 CD	1	Yes	Not reported	Yes	Short	No
	Tromp et al, 2001	1285 CD		Yes		Yes		
	Stalenhoef et al, 2002	238 CD		Yes		Yes, 9 mths	Short	
FES	Tinetti et al, 1990	18 CD	10		Yes	No	Medium	No
	Piotrowski et al, 1994	60 CD		No		No		
	Tromp et al, 2001	1285 CD		Yes		Yes		
	Hotchkiss et al, 2004	118 CD		No		No		
ABC scale	Powell et al, 1995	60 CD	16	No	Yes	No	Medium	No
	Hotchkiss et al, 2004	118 CD		No		No		
One-leg balance	Vellas et al, 1997	316 CD	1	No		Yes	Short	No
	Nevitt et al, 1989	325 CD		Yes		Yes		
	Maki et al, 1994	100 CD		Yes		Yes		
	Gerdham et al, 2005	984 CD		Yes		Yes		
	Giorgetti et al, 1998	21 CD			Yes			
Romberg	Stalenhoef et al, 2002	238 C D	1	Yes	Not reported	Yes, 9 mths	Short	No
Sit to stand	Sherrington et al, 2005	30 CD & H	1		Yes		Short	No
	Tromp et al, 2001	1285 CD		Yes		Yes		
	Delbaere et al, 2006	263 CD		Yes		Yes		
	Nevitt et al, 1989	325 CD		Yes		Yes		
FRT	Duncan, 1990	128 CD	1		Yes		Medium	Minimal
	Rockwood et al, 2000	1161 CD			Yes			
	Brauer, 2000	100 CD		No		Yes, 6mths		
Lateral reach	Brauer, 1999, 2000	100 CD	1	No	Yes	Yes, 6mths	Medium	Minimal
Timed walk	Piotrowski et al, 1994	60 CD	1	Yes		No	Short	No
	Murphy et al, 2003	45 CD		Yes		Yes		
	Tiedemann et al, 2005	30 CD			Yes			
Step Test	Hill et al, 1996	51 CD	1		Yes		Medium	Minimal
	Dite et al, 2002	81 CD		Yes		No		
	Brauer, 2000	100 CD		No		Yes, 6mths		
FSST	Dite et al, 2002	81 CD	1	Yes	Yes	No	Medium	No
MSL	Medell et al, 2000	22 CD	6	Yes	Yes	No	Medium	No
	Cho et al, 2004	167 CD		Yes	Yes	No		

Assessment	Author, date	Population *	Items	Validity	Reliability	Prospective follow-up	Time **	Equipment needed?
RST	Medell et al, 2000	22 CD	1	Yes	Yes	No	Medium	No
	Cho et al, 2004	167 CD		Yes	No	No		
Floor transfer test	Murphy et al, 2003	45 CD	1	Yes	No	Yes	Short	No
PPT	Reuben et al, 1990		9		Not reported		Medium	Extensive
	VanSwearingen, 1998	84 CD		Yes		No		
	Delbaere et al, 2006	263 CD		Yes		Yes		
BBS	Berg, 1995		14		Yes		Long	No
	Lajoie et al, 2004	125 CD &NH		Yes		No		
	Thorbahn et al, 1996	66 RV		Yes	Yes	Yes, 6 mths		
	Boulgarides et al, 2003	99 CD		No		Yes		
	Chiu et al, 2003	78 CD		Yes		No		
TUG	Podsialdo et al, 1991	70 CD	1		Yes		Short	No
	Rockwood et al, 2000	1115 CD			Poor			
	Boulgarides et al, 2003	99 CD		No		Yes		
	Rose et al, 2002	134 CD		Yes		No		
	Shumway-Cook et al, 2000	30 CD		Yes		No		
	Dite et al, 2002	81 CD				No		
	Chiu et al, 2003	78 CD		Yes		No		
EMS	Smith, 1994	15 H	7		Yes		Medium	Minimal
	Chiu et al, 2003	78 CD		Yes		No		
	Spilg et al, 2003	76 H		Yes		Yes, 4 mths		
POMA	Tinetti, 1986	336 CD	22	Yes	Yes	Yes		No
	Chiu et al, 2003	78 CD		Yes		No		
FEMBAF	Arroyo et al, 1994	241 CD	40				Long	No
	Di Fabio and Seay, 1997	35 CD		No	Yes	No		
EFST	Cwikel et al, 1998	283 CD		Yes	Not reported	Yes	Long	No
Fall-risk screening test	Tromp et al, 2001	1285 CD	4	Yes	Not reported	Yes	Short	No
Stalenhoef et al model	Stalenhoef et al, 2002	311 CD	4	Yes	Not reported	Yes 9mths	Long	Extensive
PPA	Lord et al, 1994	341 CD	5	Yes	Yes	Yes	Long	Extensive
	Lord et al, 1991	84 RV		Yes		Yes		

* CD= community-dwellers, H= hospital patients, NH= nursing home residents, RV= retirement village residents
**Administration time: short= <1min, medium= 5-10 mins, long= 15mins +

2.6 The role of the general practitioners in falls prevention

General Practitioners (GPs) have an important role to play in health promotion and disease prevention since they see over 86% of the population each year [118], with a median number of five visits per person [119]. They are able to link prevention with holistic care and their patients view them as a credible source of preventive advice; Australian research has shown that a large proportion of the population feel that lifestyle issues should be discussed as a routine part of medical consultations [120]. GPs may be able to play a key role in preventing falls in elderly people through risk assessment and intervention, since only one-quarter of falls amongst community-dwelling people are reported - 75% of which are reported to a GP, with the other 25% reported to accident and emergency departments [121]. It seems therefore that if GPs are in an important position to carry out risk assessments and to implement prevention interventions. To do so, they need to have the knowledge and tools to carry out these assessments effectively and efficiently so that falls prevention can be included into the regime of usual care for their elderly patients.

The Royal Australian College of General Practitioners (RACGP) has published a document entitled Preventive Activities in General Practice (also known as the Red book) [122]. In this document, the RACGP has recognised only a small number of screening activities for which there is enough scientific evidence to support the conclusion that screening does more good than harm. Encouragingly, falls risk factor screening is one of the activities that is supported.

Furthermore, previous research has assessed the role that GPs play in preventive medicine with the conclusion being that it is an appropriate and important role. This is a view held by both the GPs themselves and by their patients [123]. A randomised controlled trial (RCT) conducted by Kerse et al [124] examined the effectiveness of an educational intervention delivered by general practitioners aimed at improving the health and wellbeing of elderly patients. The results showed that the elderly patients of the GPs who received the educational intervention had improved health outcomes as revealed by increases in physical activity and pleasurable activities as well as improved self rated health. The authors concluded that GPs play an important health promotion role for elderly patients. Similarly, a large randomised controlled trial carried out in Belfast examined the value of health education in general practice for reducing cardiovascular disease risk factors in angina patients [125]. Although the results showed no significant effect on objective cardiovascular risk factors, dietary and exercise habits did improve, leading to the conclusion that health education delivered by a GP was useful in improving quality of life.

The majority of research into the effectiveness of GP delivered health promotion advice have focussed on smoking cessation, poor diet, sedentary behaviour and excessive alcohol consumption [126]. A systematic review of these programs concluded that GPs can have a modest and variable effect on lifestyle change in relation to these factors, but that more GPs need to adopt a health promotion approach and high-risk patient groups need to be targeted to bring about a greater public health effect.

The value of written health promotion advice from a GP as opposed to verbal advice alone was demonstrated in a RCT conducted in New Zealand [127]. The outcome was that written advice in addition to verbal advice from a GP was significantly more effective in motivating patients to increase their physical activity levels compared to verbal advice alone. This result may be translated to mean that health promotion advice needs to be specific and explicit for it to have the greatest impact.

One study that examined the level of interest that GPs show in falls prevention was the Falls STOP project [128], which involved collaboration between the Gold Coast Division of General Practice and the Gold Coast Hospital Occupational Therapy Service. The aim of the project was to reduce accidental falls in the elderly and it involved a home visiting service by the Occupational Therapist (OT), which included education about falls prevention strategies, the organisation of home modifications and referral to other community services where needed. The service was free of charge and all GPs in the area were encouraged to refer their elderly patients to be assessed. Despite this, only 5% of all GPs in the particular Division referred patients to the service, a very poor response rate especially considering that around 15% of the Gold Coast population is aged 65 years and over. The GPs that did participate in the project reported that the OT service was a valuable addition to the medical management of their patients and that their interest and awareness of falls risks had been improved by their involvement. While the collaborative approach appeared to have many benefits, the main issue for future research that came out of this project was that more strategies are needed to encourage GPs to become more involved in preventative health programs.

A more recent study was conducted in the United States of America [56] which aimed to investigate the detection of falls and mobility disorders and the management of these problems provided to community-dwelling older people by two large managed care organisations. The subjects were 372 people (64% were female) aged 65 years and over who were identified as being vulnerable, as assessed with the Vulnerable Elder Survey-which identifies people who have four times the risk of functional decline or death over the next 2 years, compared to people who are not vulnerable [129]. Process of care quality indicators (QIs) were formulated by clinical experts which related to the evidence for the assessment and treatment of older people in relation to falls and mobility problems. Examples of these QIs were such things as asking about the occurrence of falls annually, investigation of balance and gait disturbances in vulnerable older people and offering an exercise program to people with identified problems with gait, strength or endurance. The medical records of the subjects during a 13 month period were then examined to determine the level of care received by the patients in relation to any problems that arose. In addition, subjects were also interviewed to ask subjects about aspects of their care that may not be apparent in the medical records. The overall results of the study showed that falls were under-detected- 15% of the subjects had a documented history of falls, which is about half of the usual prevalence in community groups [5, 130]. Furthermore, when falls were documented, few physical examinations were carried out to ascertain the causes of the fall and structured intervention programs were often not put in place to reduce the risk of future falls. The disappointing results of this study further reinforce the need for education and training of medical practitioners regarding the importance of regularly assessing older people for their risk of falls and the management of risk factors for better health outcomes.

2.7 The role of allied health professionals in falls prevention

Physiotherapists have the skills and knowledge to assess risk factors for falls and to implement intervention programs designed to reduce risk. They are particularly well equipped with knowledge regarding exercise interventions to reduce risk as well as the skills needed to advise older people about the use of injury-reducing equipment such as hip protectors and mobility aids [131]. This is demonstrated in the results of several previous studies that have included a physiotherapist-prescribed exercise program designed to reduce falls in older community-dwelling people, with the outcome of fewer falls and improved balance [132, 133, 134].

There is also evidence from the United Kingdom [135] that practice nurses are an effective means of developing and delivering preventive advice within General Practice. The role of practice nurses in falls prevention was also evaluated in a recent project conducted by the Royal College of Nursing Australia (RCNA), which aimed to develop a national falls prevention and assessment education program which was designed for general practice nurses. The project aimed to increase the nurse's knowledge and understanding of falls risk factor assessment and intervention strategies which can be used in the general practice setting. Additionally, a project run by the Association for Australian Rural Nurses (AARN) had a similar aim to the RCNA project in a slightly different setting. It aimed to develop a resource for rural and remote nurses to improve their knowledge of falls in the elderly and allow them to undertake clinical and environmental assessments with community-dwelling people in rural and remote locations in Australia.

The value of the contribution of practice nurses to falls risk assessment and prevention in the clinical setting was also evident in a project that aimed to improve the knowledge and skills about falls risk assessment and prevention in general practice settings in Tasmania [136]. The project report concluded that although most of the GPs involved in the initiative were supportive of the use of the falls risk assessment with their elderly patients, all of them actually relied upon their practice nurses to carry out the assessments. More detailed information about the outcomes of these projects is included in chapter seven.

2.8 Fall risk assessment carried out by clinicians in previous research

Previous research makes it clear that a high proportion of clinicians believe that the way to assess a person's risk of falling is to use clinical judgement and informal observation of behaviours of the patient. An example of these attitudes was apparent in a baseline survey of practice nurses which was carried out as part of a falls prevention initiative in seven medical centres in Tasmania [136]. Prior to the implementation of a validated falls risk assessment, several nurses reported that the way they found out that a person was at risk of falling was through general observation, discussion, questioning the patient and when a patient presented to the clinic after suffering a fall.

Furthermore, the report that arose from the AARN project mentioned above [137] included the results of an initial pre-workshop survey which showed that among rural health professionals who were required to conduct falls risk assessments as part of their employment duties, 78% of respondents (with registered nurses being the most highly represented) stated that they had not received any training in falls risk assessment and prevention in the previous year despite these being requirements of their role. This is despite 50% of these respondents stating that they conducted assessments three to five times each week.

These facts are worrying, in light of previous research that has shown that the use of clinical judgement alone can not be relied upon to determine the absence or presence of disease and risk factors for decline in health. Pinholt et al [138] investigated the sensitivity of clinician judgement in detecting impairment in several health domains, including visual acuity and gait. They found that clinicians were adept at recognising severe impairments, but poor at detecting moderate impairments in several areas, including visual acuity impairment, where the sensitivity of detection was just 27%. Therefore, it is essential that clinicians are trained in the use of standardised, validated assessment tools for the detection of falls risk factors.

A review of published randomised controlled trials of health assessments for older people aged 65 years and over and living in the community [139] identified 21 relevant trials. Of these, the studies that had good methodologies generally resulted in improvements to health. It was also apparent that improvements to health were obtained regardless of whether the assessment was carried out by a GP or by a trained health professional or lay interviewer/ volunteer. Studies such as this therefore reinforce the importance of health assessments and the need for awareness building amongst GPs and other health professionals regarding the impact they can have on the health and well-being of older people.

Falls risk screening was included in a study carried out to examine the benefit of using simple instruments in detecting various geriatric conditions in a community setting [140]. Disease and disability were assessed in 139 patients, aged 65 years and over, using a comprehensive geriatric assessment (CGA). The CGA is a three-step process consisting of: (1) targeting appropriate patients; (2) developing recommendations; and (3) implementing recommendations. The falls assessment component consisted of asking the patient if they had fallen in the previous 12 months. The study resulted in high implementation and adherence rates to recommendations and concluded that CGA is an effective means for improving health status and quality of life in elderly patients.

From 1998 to 1999 a program was conducted by the Southern Highlands Division of General Practice which aimed to encourage GPs to conduct falls risk assessments with their patients aged 65 years and older. The GPs were given a falls risk assessment tool that included a checklist of possible risk factors such as balance and gait problems, foot and footwear deficits, medications and sensory impairments and information on preventive strategies. There was also a community education campaign carried out which aimed to increase awareness about falls risk factors and encourage older people to request a falls risk assessment from by their GP. Unfortunately an impact evaluation was not carried out to assess the success of the program in improving awareness or reducing falls [141].

2.9 Barriers associated with preventive health care in the clinical setting

While it is clear that practising prevention is an important role for GPs and other health professionals, several barriers to effective implementation of preventive strategies have been identified [119]. One of the obvious barriers is lack of time. Most clinicians work within a demanding schedule and it can appear that there is little opportunity to provide extra patient services in the space of a usual consultation time. The average Australian general practice consultation lasts 14.6 minutes and more than 40% of these consultations involve attending to two or more patient problems [142]. This leaves very little time to address health promotion or disease prevention issues and further reinforces the need for an assessment tool that is to be used in this setting to be quick and easy to administer. Furthermore, lack of time is a barrier that is reported by other health professionals. A survey by the AARN following the conclusion of the falls prevention and assessment project mentioned above, showed that the main reason given by participants for not conducting falls risk assessments even when the assessment tool and knowledge of how to use it were provided, was lack of time. This sentiment was also echoed in the results of a survey of practice nurses who were involved with a falls prevention education initiative [136].

Financial barriers to health promotion practice for older people are also commonly cited by GPs, however, the annual health assessment items which were introduced on the Medicare Benefits Schedule (MBS) as part of the Enhanced Primary Care (EPC) Package in November 1999 may encourage GPs to become more involved in prevention. The EPC initiative aims to improve the quality of care for older people and those with chronic and complex health care needs. To achieve this outcome, one of the strategies is to strengthen the role of GPs in primary care. In addition, the MBS item allows for the involvement of other health professionals such as registered nurses, to carry out the assessments as part of the primary health care team. The EPC MBS items pertain to people over the age of 75 years (over 55 years in Aboriginal and Torres Strait Islanders) and allow payment for an annual health assessment, covering several areas of health promotion and disease prevention including falls prevention. Since people have an increased risk of falling from age 65 years and onwards however, confining the assessment of falls risk factors to the annual health assessment mentioned above, would exclude a large proportion of people who would benefit from being given prevention advice at an earlier age.

A survey was conducted five months after the initiation of the EPC items to assess the uptake and usage of this initiative among GPs in South West Sydney [143]. The results showed that 73% of the GPs surveyed had heard of the EPC package yet only 27% of them had used any of the EPC items. Additionally, a large proportion (62%) of the GPs who had not used the EPC items stated that they had no firm plans to use the items in the future and most of the remaining GPs asserted that they would use the items opportunistically rather than by inviting all patients or a selection of their patients to use the services. So, even when the issue of payment for health promotion services is addressed, the barriers to implementing these services in the general practice setting appear to remain.

Another barrier cited in the literature is a lack of resources and knowledge needed to carry out preventive activities, which may be caused by a lack of emphasis on health promotion skills in undergraduate medical training [144]. Research has shown that only 13% of GPs attend continuing medical education activities which are related to health promotion [145]. This may be because GPs perceive themselves to lack the counselling skills necessary to bring about behaviour change and may also lack confidence that preventive interventions will be successful.

In 2004 the Royal Australian College of Physicians conducted 13 national workshops as part of the Falls Prevention for Older People Program. The workshops related to falls injury risk factors and strategic interventions and were attended by 290 physicians and other health professionals. A workforce survey [146] was conducted prior to the workshops being held, to assess the level of knowledge of falls risk factors and interventions amongst various health professionals, managers and health promotion officers. The results showed that only 55% of the 116 respondents believed that they had a sufficiently comprehensive level of knowledge about falls in older people. The respondents had a minimal level of awareness relating to falls risk screening tools and an even lower level of regular usage of such tools. Additionally, only 51% of survey respondents had read an academic paper in the previous six months which related to falls and a large proportion of the respondents stated that they did not refer to falls clinical guidelines as a source of information about falls, but more than half of those surveyed did use internet sites to access falls information. This reinforces the need for greater awareness building regarding falls risk and about the role that clinicians can play in assessment and prevention.

Insufficient infrastructure at the practice level is also a significant obstacle in the path of effective health promotion service delivery [144]. This may include lack of staff support, such as practice nurses, who are utilised in other countries such as the United Kingdom, to carry out general practice health promotion activities [147]. Nurses are less commonly employed by general practices in Australia because, apart from the items in the EPC package, there is no direct way of funding nurses for clinical activities.

Lastly, since the effects of health promotion or preventative interventions are not readily apparent, unlike many medical interventions, GPs do not gain immediate feedback about the benefits of the intervention which may lead to uncertainty about its effectiveness [144].

These barriers need to be considered when formulating preventive health care programs for clinicians to implement with their elderly patients. To address these barriers, any falls risk assessment which is to be implemented in clinical settings needs to meet the following criteria-

- The assessment needs to be quick to administer, ideally it should take less than 15 minutes to carry out (the usual GP consultation time).
- The assessment should require little or no equipment so that the purchase cost does not become a barrier to implementation.
- The assessment tool should be portable so that it can be taken to different settings, allowing for the assessment of less mobile individuals.
- The assessment should be robust, so that it can be used with many patients over an extended period of time.
- The assessment should be simple to administer so that clinicians can become familiar with it quickly.
- The assessment should be acceptable to elderly patients, in that it should not cause pain or discomfort, yet should be challenging enough so as to discriminate between fallers and non-fallers.

- The assessment should have scientific evidence regarding its validity and reliability for use in a clinical setting.
- As well as being a tool for assessing or predicting risk, the assessment should include intervention strategies to reduce identified risk factors.

In summary, GPs and allied health professionals need to believe that health promotion and disease prevention is an important and worthwhile part of their role as health care providers in order to encourage more of them to carry out falls risk assessment and prevention activities. They need to realise that it is sustainable and feasible for them to include health promotion and disease prevention as a routine part of their patient care [119]. With these issues in mind, this study set out to develop an appropriate falls risk assessment which was able to be used effectively in a variety of clinical settings.

Chapter Three

Rationale for the study

3.0 Why was this study needed?

The literature review included in the previous chapter provides a summary of the various falls risk assessments that have been developed for use with community-dwelling older people. It is apparent from the number of different assessments summarised that there are a variety of measures available with differing levels of evidence to support their use in identifying older people who are at risk of falls.

Many of these assessments however only measure a single risk factor, usually balance, which means that older people who are at risk of falling due to deficits in other sensorimotor factors or due to medical factors such as medication use may not be identified as being at risk and will therefore not receive remedial interventions. The Berg Balance Scale (BBS) [148] is one such assessment, which is commonly used by clinicians and yields information about a person's mobility and balance only. In addition, the BBS is time consuming to administer (taking 15-30 minutes) and its validity and usefulness in determining falls risk in active, community-dwelling older people has not been established due to significant ceiling effects in this population group [103, 105].

Similarly the Timed Up and Go (TUG) test [74] predominantly assesses mobility and has been recommended as an initial screening test to assess risk of falling in older adults [54]. However, while the TUG is quick and easy to carry out, it is only able to identify people a generalised mobility deficit and its accuracy in predicting fallers has not been verified in studies with a prospective measurement of falls [149], making its predictive validity uncertain.

A more comprehensive, multifactorial falls risk assessment is the Elderly Falls Screening Tool (EFST) [59]. The EFST takes more than 15 minutes to administer and consists of five items: number of falls in the past year, number of injurious falls in the past year, number of near falls in the past year, timed five metre walk and presence of gait abnormalities. The EFST has been shown to be a valid predictor of falls in the study of community-dwelling older people where it was developed, but validation in a separate population has not been undertaken. Inter-rater and test-retest reliability of the EFST has not been reported and this is important as two of its measures- the frequency of near falls and the measurement of gait abnormalities - may have less than acceptable reliability. This is due to the limited accuracy with which older people can recall falls, let alone near falls [100] and also due to the subjective nature of observing and scoring gait abnormalities, especially by clinicians who have not had extensive training in the area of gait assessment [150].

Therefore, the assessment measures outlined in the literature review in chapter two are not ideal for the identification of older people who are likely to fall for several reasons. Firstly, many of the assessments are measuring single risk factors for falls, usually strength, balance or mobility, which means that other important risk factors are likely to be overlooked. Secondly, several of the assessments, including four out of the five multifactorial assessments outlined, are too time consuming to be practical for use in many clinical settings where time constraints are a major issue. The complicated and time-consuming nature of the scoring methods for some of the risk assessment measures, such as the Fast Evaluation of Mobility, Balance and Fear [114] would also be a barrier to their use by busy clinicians who require a quick and easy to score and interpret set of measures if risk assessment is to become a standard clinical practice. Furthermore, to be effective in the prevention of future falls, a risk assessment should not only identify those people who are likely to fall, but it should also guide intervention strategies which can be instigated easily from the interpretation of the assessment result. Many of the assessments included in the literature review do not guide interventions, leading to a need for further clinical investigation if appropriate interventions are to be tailored to individual need.

3.1 The Physiological Profile Assessment

The Physiological Profile Assessment (PPA) [117] is one of the multifactorial assessments included in the literature review in chapter two which has had its reliability and validity extensively tested in several large samples of community-dwelling older people. In contrast to medical screens, the PPA approach to assessing falls risk involves quantitative assessment of sensorimotor and balance abilities. Physiological factors that are the primary contributors to stability are shown in Figure 3.1. Functioning in each of these factors declines with age [151], and impairments in each factor increases the risk of falling [28, 31, 48, 152]. A marked deficit in any one of these factors may be sufficient to predispose an older person to fall; however, a combination of mild or moderate impairments across physiological domains also may increase the risk of falling. By assessing an individual's physiological abilities, impairments in one or more physiological domains can be identified, and cumulative falls risk can be determined.

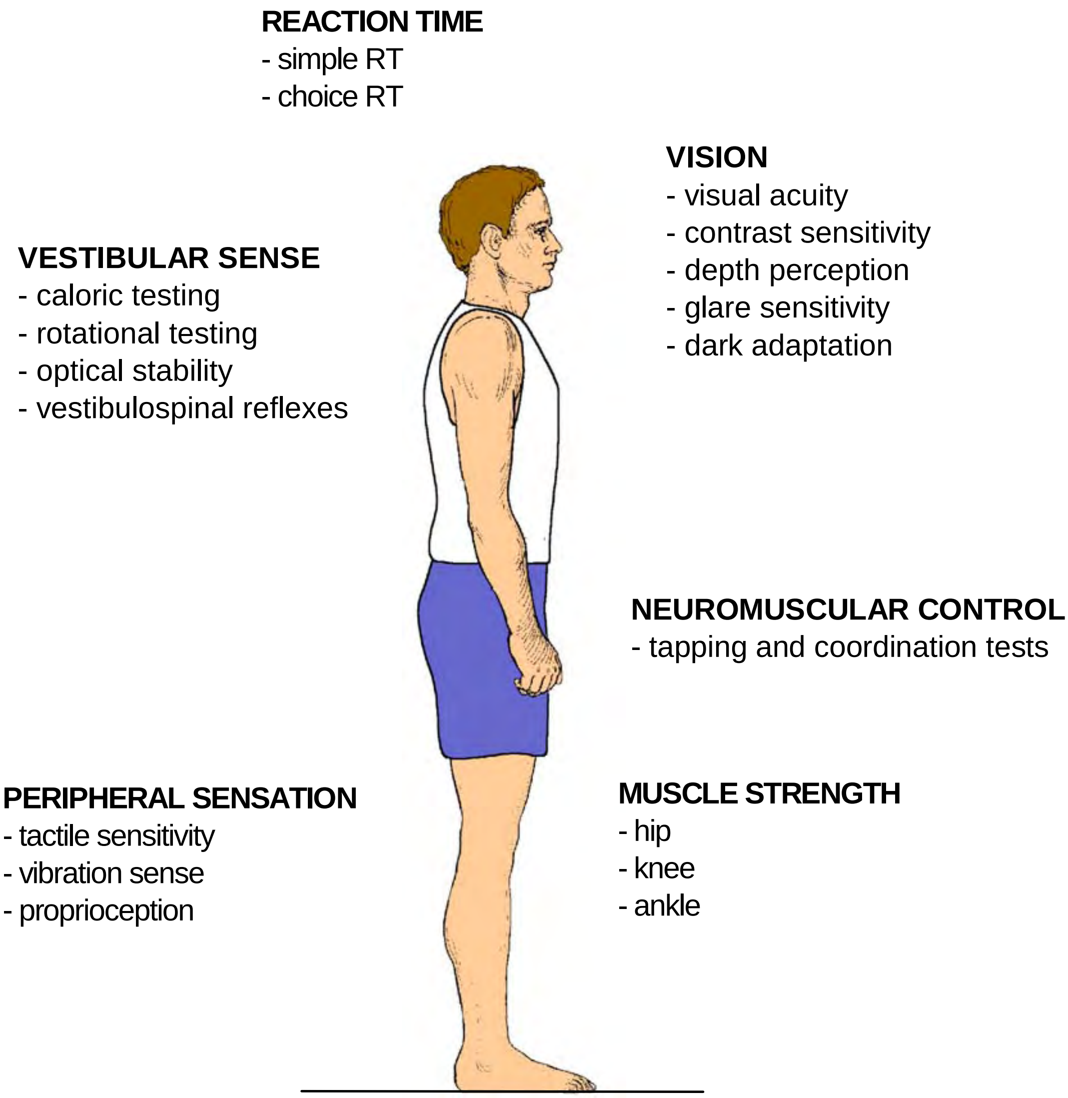

Figure 3.1 Physiological factors that are the primary contributors to stability and some common methods used to assess them [117].

In many cases the postural effects of medical conditions, whether diagnosed or not, will be manifest in one or more of the PPA tests. For example, poor vision is likely to be the prime impairment and risk factor for falls in older people with cataracts or macular degeneration. Similarly, poor peripheral sensation is likely to be a major falls risk factor for people with diabetic neuropathy, and muscle weakness the main risk factor for people with prior poliomyelitis. Finally, older people following a stroke or those with limiting arthritis or multiple pathologies may have several impairments including poor peripheral sensation, muscle weakness, slowed reaction time and poor balance.

The PPA has proved to be a comprehensive falls risk assessment which is able to predict future fall status with an accuracy of 75% [31] and its measures have good test-retest reliability, are simple to administer, feasible for older people with differing levels of physical frailty to undertake and can be used to tailor interventions to individual need.

However, while the PPA has been used extensively in both clinical and research settings in locations across Australia and internationally, it is not practical for use in all clinical settings. Primarily, the PPA requires the use of specialised equipment and the data obtained requires computer processing, which has cost and time disadvantages over other simple assessments. Therefore, this study arose out of the need to provide clinicians with a falls risk tool which had a similar function-based assessment framework as the PPA, but which was more time and cost-efficient in order to make it more practical for use in a range of clinical settings.

3.2 Clinical falls risk assessment measures- rationale for selection and test descriptions

To address the barriers associated with the use of falls risk assessments by many clinicians, potential tests chosen for inclusion in the clinical risk assessment tool were evaluated against a number of criteria, in that they need to be quick and simple to administer and require no or readily available equipment items. Further, assessments were chosen to encompass the major neuro-physiological domains measured by the PPA (vision, sensation, lower limb strength, reaction time, coordination and balance), as well as more global measures of stability and mobility. The following section describes the tests selected and the rationale for their possible inclusion in the assessment tool. Additional screening and assessment items relating to previous falls and medication use were also considered for inclusion in the assessment to maximise predictive accuracy and provide supplementary information regarding potential intervention strategies.

LOWER LIMB STRENGTH

The sit to stand test with five repetitions

The sit to stand test is often used as a measure of lower limb strength [76] and is included in a number of fall risk assessment scales [64, 65, 75]. Additionally, slow sit to stand times have previously been associated with slow walking speed, poor balance [68] and falls in older people [8, 32].

For the sit to stand test with five repetitions, subjects were asked to rise from a standard height (43cm) chair without armrests, five times as fast as possible with their arms folded (see Figure 3.2). Subjects undertook the test barefoot and performance was measured in seconds using a stopwatch as the time from the initial seated position to the final seated position after completing five stands.

Figure 3.2: The sit to stand test

The sit to stand test with one repetition

This test assessed how quickly subjects could stand up once from a seated position. The single repetition sit to stand task is also used in several assessment scales [148, 153] as a measure of functional mobility, balance and lower limb strength. The chair and arm position were the same as in the sit to stand test with five repetitions. The time taken to complete the task, measured in seconds, was the score.

Two versions of the test, with five repetitions and one repetition were included in the study to determine which displayed superior reliability and validity. If the results were found to be comparable, it would be preferable to include the one repetition version in the screening tool since it may be more feasible for older people to undertake and require less time to administer.

REACTION TIME

The rod catch test

The rod catch test was developed by Lord and colleagues [27] as a measure of reaction time that required only a very simple, low tech piece of equipment - a rod marked in increments indicating time in milliseconds that the rod falls under gravity when dropped from a stationary position. The increments were indirectly derived from the formula: $s = u + at^2$, where s =displacement, u = initial velocity (in this case zero), a = acceleration due to gravity ($9ms^{-2}$) and t= time.

For this test, the seated subject was instructed to catch as quickly as possible a wooden rod that was dropped vertically without notice from immediately above the dominant hand (see Figure 3.3). After one practice trial, the position at which the subject caught the rod (indicated from a millisecond increment mark at the top of the hand) was recorded. The average time for the five test trials was taken as the test measure.

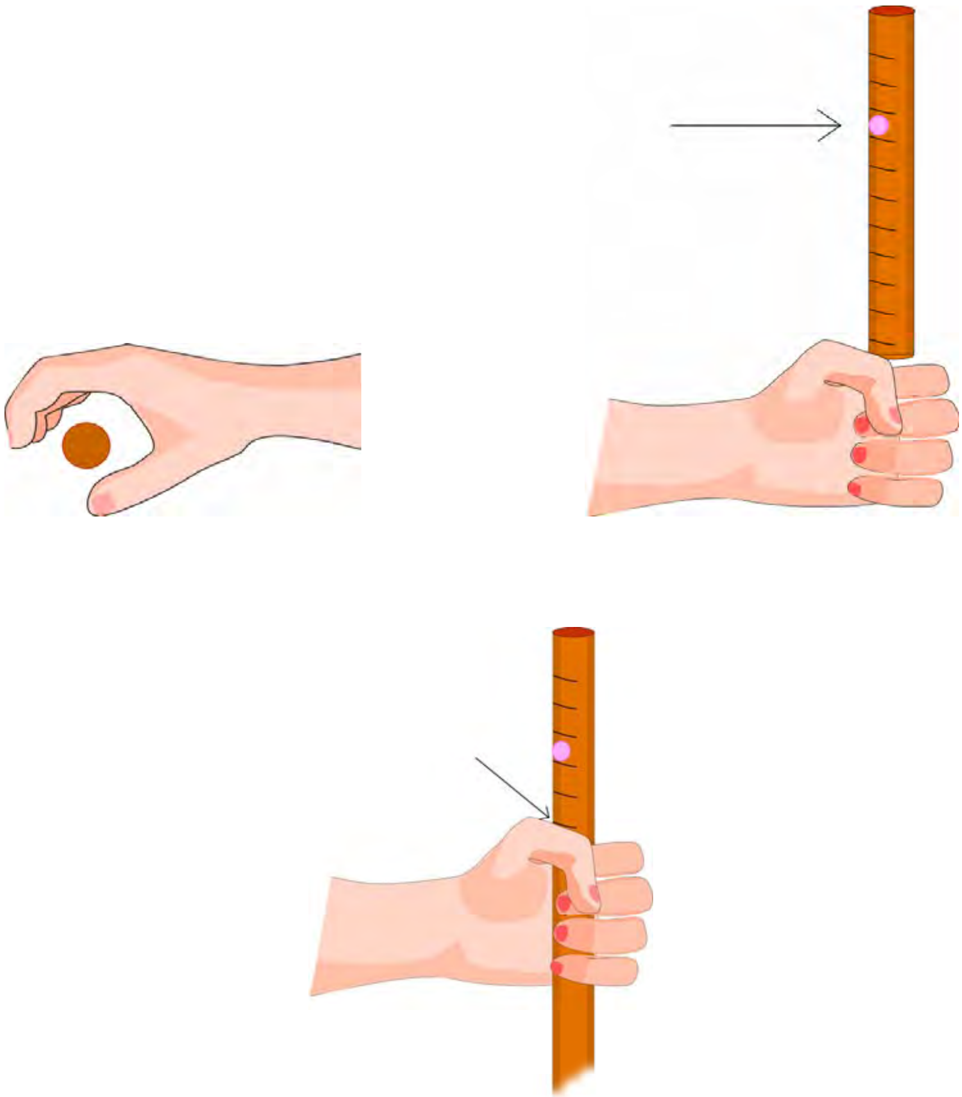

Figure 3.3: The rod catch test. The hand position at test commencement viewed from above (top left), the initial position of the rod viewed from the side (top right) and final position for the rod after the subject caught the rod (bottom). Time to catch the rod was recorded from the millisecond increment marks inscribed on the rod and read at the top of the hand.

STANDING BALANCE

The near tandem stand test

The tandem stand test, where subjects are required to stand heel to toe and balance with their eyes open or closed for a specified period of time, has been used to measure lateral stability and has been shown to identify older people at risk of falls [37, 154]. Many older people however, are unable to attempt the test, especially with their eyes closed, which makes its use limited [155]. To account for this problem, Lord et al developed the near tandem stand test, [156] to minimise floor effects. These authors found this test to be predictive of falls and to be associated with other physical measures which are related to falling, including impaired lower limb proprioception, quadriceps strength and reaction time.

In this test, subjects were asked to stand in a near tandem position with their bare feet separated laterally by 2.5cm and the heel of the front foot 2.5cm anterior to the great toe of the back foot (see Figure 3.4). Subjects chose which foot to place in the forward position for the test and he/she was required to stand in this position for 30 seconds with eyes closed. The time that subjects were able to stand in this position before a step was taken or the eyes were opened was the score. If a score of 5 seconds or less was obtained, a second trial was allowed and the better result was used as the test score.

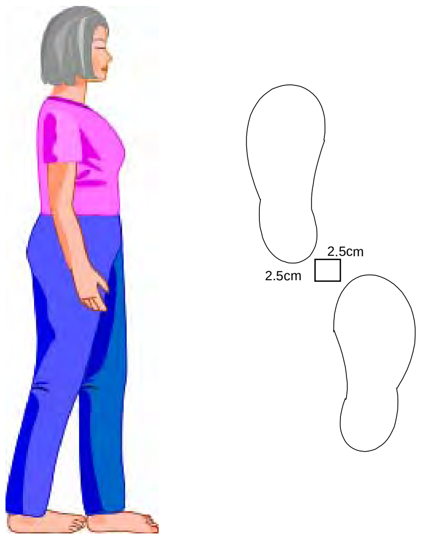

Figure 3.4: The near tandem stand test, body and foot positioning

LEANING BALANCE

Pick up weight from floor test (pick up weight test)

The ability to reach down and retrieve an object from the floor is a task that has been included in several functional assessment scales previously [98, 148] and is a measure of dynamic stability.

For this study, a bag containing a 5kg weight with handles that extended 50cm above the floor was placed on the floor in front of the subject. They were then asked to pick the bag up and place it on the table next to them by using one hand only. Performance in the task was rated dichotomously as either able or unable to complete the task.

TURNING

Half turn test

Measures of a person's ability to turn around in a safe and efficient manner have been utilised in assessments of mobility and balance in older people previously [74, 148] and performance has also been able to predict fall status [32]. For the half turn test, subjects were asked to take a few steps and then turn around to face the opposite direction. The number of steps taken to complete this 180 degree turn was measured.

STEPPING

The alternate step test

The alternate step test is a modified version of the stool stepping task - one of the 14 components of the Berg Balance Scale (BBS) [148]. It is a measure of the requirements of walking and stair climbing [148] since it involves weight shifting from one foot to the other and hence is a measure of medio-lateral stability. In addition, a recent study has found that this item of the BBS is one of three items which best discriminate between single and multiple fallers in the older age group [104]. As the test requires only the use of a low stool and has previously demonstrated good reliability and validity as part of the BBS, it was considered to be an appropriate measure for inclusion in this study.

This test involves alternatively placing the whole left and right (bare) foot as fast as possible onto a step that was 19cm high and 40cm deep – see Figure 3.5. The time taken to complete a total of eight steps, alternating between left and right foot comprised the test measure.

Figure 3.5: The alternate step test

The scoring method used in this study, time taken to complete the task, differed to that used originally, which comprised a subjective rating on a four-point scale of how difficult the task was for the person to complete.

GAIT

Six metre walk test

Slowed gait speed has previously been associated with an increased risk of falls [82, 83] and it is a factor which is measured in several fall risk assessment scales [61, 74].

In this study, subjects were asked to walk along a well-lit corridor at their normal walking speed. Two markers were used to indicate the start and end of the six metre path and a two metre approach was allowed before reaching the start marker so that subjects were walking at their normal pace within the timed path. The subjects were also instructed to continue walking past the end of the six metre path for a further two metres to ensure that the walking pace was kept consistent throughout the task. The time taken to complete the task, measured in seconds was the score.

VISION

Visual acuity

Vision was assessed with the low contrast visual acuity test which is one of the vision tests that is included in the Physiological Profile Assessment (PPA) [117]. It was included in the study since performance in tests of visual acuity have previously been associated with risk of falling in older people [31, 38, 157]. The low-contrast visual acuity test was selected rather than the high contrast test as it has been shown to be more predictive of multiple falls [152]. Furthermore, the visual acuity test is more feasible for inclusion in a clinical falls risk assessment compared with other vision tests such as depth perception and edge contrast sensitivity because it is quick and easy to administer, the equipment required is simple and portable and the test is able to be performed by older people with a range of visual abilities.

Low contrast visual acuity was measured using a letter chart with low (10%) contrast letters (see Figure 3.6). The chart was positioned at a distance of three metres and vision was measured binocularly. Subjects wore their usual distance glasses (if applicable) and were seated in front of the chart. The lowest line they could read and the number of letters they correctly identified on that line was the score which was then converted into a score representing the minimum angle resolvable (MAR) in minutes of arc.

Figure 3.6: The low contrast visual acuity chart

PERIPHERAL SENSATION

Touch sensation

The touch sensation test is a test of peripheral sensation and is also one of the measures included in the PPA. Since it has been associated with risk of falling and postural instability in previous studies [28, 158, 159] it was considered to be an important factor for possible inclusion in the clinical falls risk assessment. Compared with other measures of peripheral sensation, such as vibration sense and proprioception, the touch sensation test is feasible for use in clinical settings since the equipment required to conduct the test is simple and portable and the test is quick and easy to administer.

Touch sensation was measured at the lateral malleolus of the ankle with eight Semmes-Weinstein-type pressure aesthesiometers (see Figure 3.7). Subjects were seated with their eyes closed and were asked to indicate if they felt the aesthesiometers as they were touched to the ankle. The finest aesthesiometer that the subject could feel was recorded and the pressure (in grams) exerted by this aesthesiometer was converted to $\log_{10}$ 0.1mg, yielding a scale of approximately equal-intensity intervals between aesthesiometers.

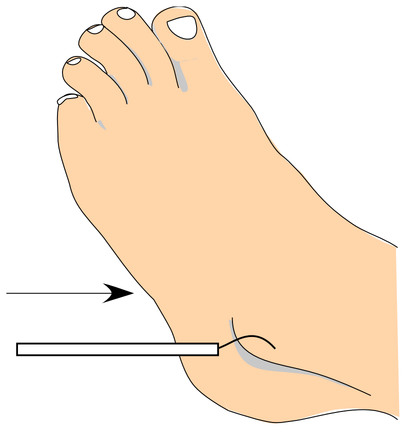

Figure 3.7: The tactile sensitivity test

Previous falls

Previous falls were assessed with the question: "Have you had any falls in the past twelve months?" Although the accuracy of retrospective recall of falls has been found to be limited [100], fall history is a previously validated predictor of future falls [4, 32, 50, 58] and hence was considered to be a useful and important addition to the clinical falls risk assessment.

Medication usage

Many previous studies have found that the use of certain medications is associated with an increased risk of falling [6, 9, 43, 160], therefore it was deemed to be an important risk factor for possible inclusion in the clinical falls risk assessment. Two measures regarding medication usage were included, firstly there was a measure of polypharmacy, where the total number of medications (excluding vitamins and minerals) currently being taken by the subject was recorded. Secondly, the number of psychoactive medications being taken was recorded.

3.3 Construct validity of the strength, balance, reaction time and mobility tests- study rationale

The functional mobility tests described above (the sit to stand with one and five repetitions, the rod catch test, the near tandem stand test, the pick up weight test, the half turn test, the alternate step test and the six metre walk test) were selected as simple, easy to measure potential alternatives to the more equipment-dependent and time-consuming tests of lower limb strength, reaction time and standing and leaning balance which are included in the PPA. Many of the functional tests outlined above have previously been considered to be composite measures of leg strength and balance, and have been suggested to be predictors of falls, yet few investigations have proven this definitively. So, since the PPA includes validated measures of important physiological risk factors for falls and it was the basis from which the clinical falls risk assessment was developed, it was important to determine the construct validity of these functional mobility tests to establish their association with the direct measures that the PPA provides. The study that was conducted to determine these associations is outlined below.

3.4 Methods

Subjects

620 subjects (211 men, 409 women) were included in the construct validity study and were recruited from a randomised controlled trial (RCT) investigating the effects of tailored interventions for falls prevention [161]. The RCT was being conducted by researchers from the Prince of Wales Medical Research Institute (including the author) and the subjects were randomly selected from a membership database of a private health insurance company. The subjects were living independently in the community and were recruited from 10 postcodes in the lower North Shore area in Sydney, Australia. The subjects ranged in age from 74 to 98 years (mean= 80.4, SD= 4.5) and the age and sex distribution of the sample is shown in Table 3.1. Subjects were excluded from the randomised controlled trial if they suffered from Parkinson's disease, were blind, had little or no English language skills or a Short Portable Mental Status Questionnaire (SPMSQ) score of less than 7 [162]. They were also excluded, if at initial assessment they were found to be at a low risk of falling, i.e. they exhibited no significant deficiencies in any of the individual physiological fall risk factors measured – 9.4% of the total sample. The prevalence of major medical conditions and limitations in activities of daily living in the study sample are shown in Table 3.2. Four research assistants (including the author) administered the PPA tests and the functional tests, which took approximately 50 minutes to complete and were carried out at the Falls Assessment Clinic at Royal North Shore Hospital, Sydney, Australia. Informed consent was obtained from all subjects prior to participation, and approval for the study was given by the Human Studies Ethics Committee at the University of New South Wales.

Table 3.1: Age and sex distribution (number (%)) of the sample in the construct validity study

Age group (years)	Men	Women	Total
74-79	108 (51)	201 (49)	309 (50)
80-84	63 (30)	139 (34)	202 (32)
85-89	29 (14)	56 (14)	85 (14)
90+	11 (5)	13 (3)	24 (4)
Total	211 (34)	409 (66)	620 (100)
Mean age (SD)	80.3 (4.7)	80.4 (4.4)	80.4 (4.5)

Table 3.2: Prevalence of major medical conditions and ADL limitations in the subjects of the construct validity study

Medical variables	Number of subjects (%)
Diabetes	26 (7)
Stroke	48 (8)
Arthritis	267 (43)
Incontinence	101 (16)
Depression	63 (10)
4+ medications	321 (52)
Had a fall in past 12 months	272 (44)
Use of a walking aid	115 (19)
Activities of daily living	
Difficulty with shopping	99 (16)
Difficulty with housework	213 (34)
Difficulty with cooking	98 (16)

Physiological profile assessment measures

The PPA includes tests of vision, peripheral sensation, muscle strength, reaction time, postural sway and leaning balance. The PPA tests are described below.

Vision

Vision was assessed by the use of four tests which measured high and low contrast visual acuity, edge contrast sensitivity and depth perception.

High and low contrast visual acuity

High contrast visual acuity and low contrast visual acuity were measured using a letter chart with high and low (10%) contrast letters. The chart was positioned at a distance of three metres (see Figure 3.8) and vision was measured binocularly. Subjects wore their usual distance glasses (if applicable) and were seated in front of the chart. The lowest line they could read and the number of letters they correctly identified on that line was the score which was then converted into a score representing the minimum angle resolvable (MAR) in minutes of arc.

Figure 3.8: The high and low contrast visual acuity chart

Edge contrast sensitivity

Edge contrast sensitivity was assessed using the Melbourne Edge Test (see Figure 3.9) [163], which presents twenty circles, 25mm in diameter that have gradually reducing contrast which are oriented in one of four possible directions- horizontal, vertical, 45 degrees left and 45 degrees right. Subjects were required to identify the orientation of the contrast for each circle and the score was the lowest contrast patch that was correctly identified. Subjects underwent the test while wearing their usual near vision lens correction as appropriate and the test was conducted in a seated position.

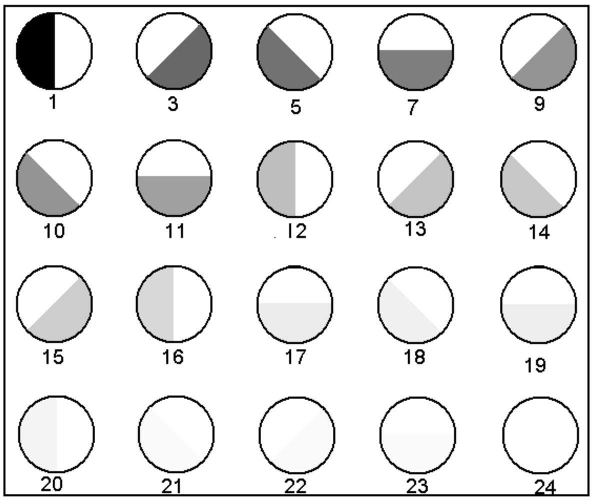

Figure 3.9: The Melbourne Edge Test

Depth perception

Depth perception was measured using a Howard-Dohlman depth perception apparatus (see Figure 3.10). Subjects were seated and wearing their usual distance vision lens correction (as applicable) and the test was conducted at a distance of three metres. The apparatus was positioned on an adjustable height table so that the aperture (through which the subject can see the two rods) was directly ahead and at the level of the eyes. The subject was advised that one of the rods is fixed in place and that the other one moves when the cords are pulled. The test protocol involved the separation of the movable rod from the fixed rod (in an anterior-posterior direction) and then the subject was required to pull on the cords to position the movable rod so that it was side by side with the fixed rod (i.e. the same distance away in the anterior-posterior direction from the subject). The error in matching the rods (measured in millimetres) was recorded and the average of four trials was the final score.

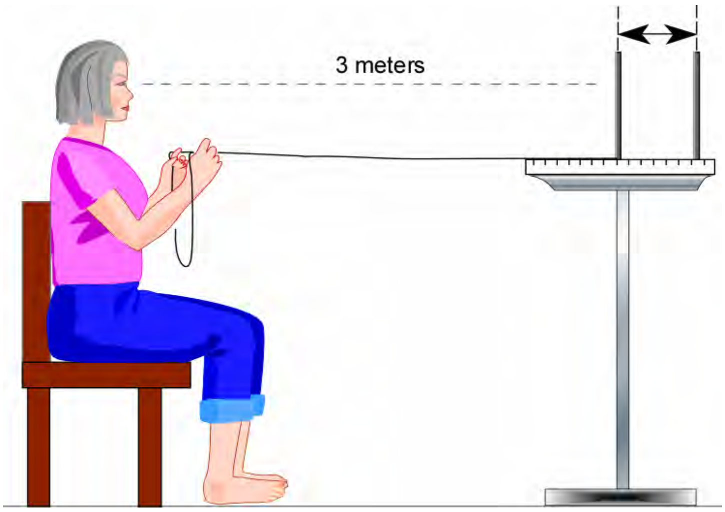

Figure 3.10: The depth perception apparatus and test position

Peripheral sensation

Three tests of peripheral sensation are included in the PPA: a test of proprioception, a test of tactile sensitivity and a test of vibration sense.

Proprioception

Proprioception was assessed using a lower limb matching task, which involved the use of a protractor marked on a sheet of Perspex (60cm x 60cm x 1cm) which was placed between the legs to allow for the measurement of errors (see Figure 3.11). After several practice trials to become familiar with the task, subjects were instructed to close their eyes and raise their feet and match them together either side of the Perspex so they were exactly lined up. Errors in matching the feet were measured in centimetres and the average of five trials was the final score.

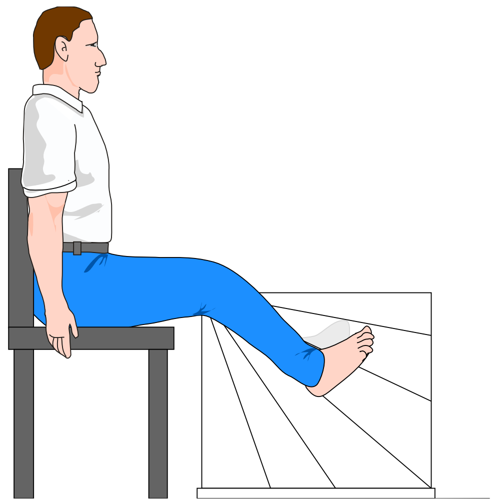

Figure 3.11: The proprioception test

Tactile sensitivity

Tactile sensitivity was measured as described on page 71 of this chapter.

Vibration sense

Vibration sense was measured at the tibial tuberosity using a vibrator which produced 200-Hz vibration at varying intensities (see Figure 3.12). The vibration was applied via a 1cm diameter rubber stopper and was measured in microns of motion perpendicular to the body surface. Three readings in both the ascending and the descending mode were made and an average of these six measurements was the final threshold score.

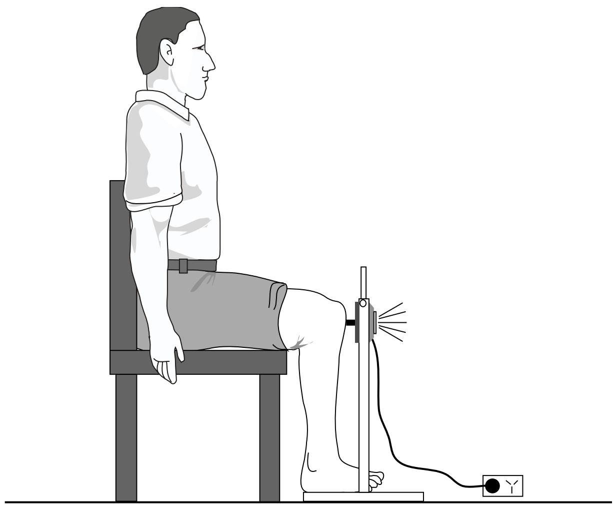

Figure 3.12: The vibration sense test

Muscle strength

The strength of three muscle groups in both legs was measured. Testing of the knee extensor and flexor muscle groups was performed using a strap assembly, incorporating a strain gauge load cell, which was connected to an amplifier with the output recorded on a digital display, measured in kilograms of force.

Knee extension

The subject was seated with the hip and knee at approximately 90 degrees of flexion. The strap was attached 10cm above the ankle so it was positioned just below the calf muscle (see Figure 3.13). The subject was instructed to hold onto the sides of the chair for support and to extend the knee maximally for approximately three seconds. The tester gave feedback and encouragement during the test procedure to get the best performance from the subject. The procedure was repeated two more times and the best of three trials was recorded for each leg. The average of the two scores was used as the final measure.

Knee flexion

The subject positioning and equipment was the same as for the knee extension test, however the strap assembly was attached to a pole which was secured in front of the leg to be tested (see Figure 3.14). This allowed the subject to flex the knee maximally against the strap assembly which they were instructed to do for approximately three seconds, again with the tester giving feedback and encouragement. This procedure was repeated two more times and the best of three trials was recorded for each leg. The average of the two scores was used as the final measure.

Ankle dorsiflexion

The measurement of ankle strength was performed using a specially designed device that used a pivoted platform attached to a spring gauge. The subject was seated on a chair, with their arms folded, the knee flexed at an angle of 110° and the foot secured to the pivoted platform (see Figure 3.15). In three experimental trials for each ankle, the subject attempted to maximally dorsiflex in the device and the greatest force was recorded in kilograms. The average of the two sides was used as the final score.

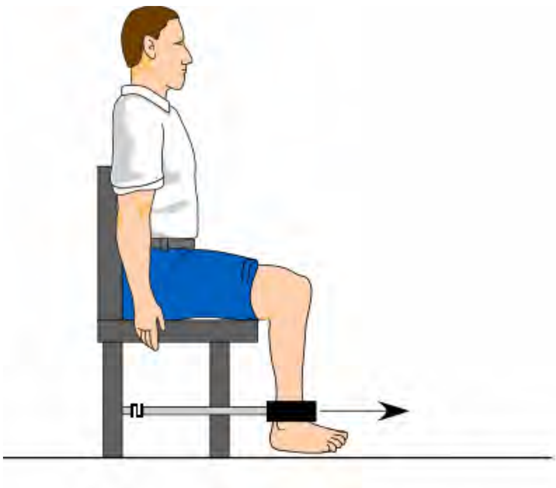

Figure 3.13: The knee extensor strength test

Figure 3.14: The knee flexion strength test

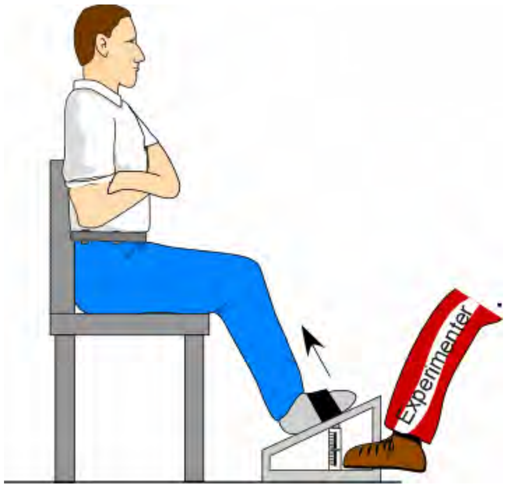

Figure 3.15: The ankle dorsiflexion strength test

Reaction time

Foot

Foot reaction time was assessed using a light as the stimulus and depression of a switch by the foot as the response. The subject was seated with the dominant foot resting on the testing pedal which was hinged to a base plate. A switch recorded how quickly the pedal was pressed, in milliseconds. The auditory cue of the experimenter's switch was eliminated by a variable delay between depression of the switch and the activation of the timer and the light stimulus (1-5 seconds). Subjects had 5 practice trials and 10 experimental trials. The final score was the average of the 10 trials (see Figure 3.16 below).

Hand

The above test was then repeated with a button press with the finger as the response. The dominant hand was rested on a modified computer mouse with a light as the stimulus (see Figure 3.17). The same switch as used in the foot reaction time recorded how quickly the mouse button was pressed. Subjects had 5 practice trials and 10 experimental trials. The final score was the average of the 10 trials.

Figure 3.16: The foot reaction time test

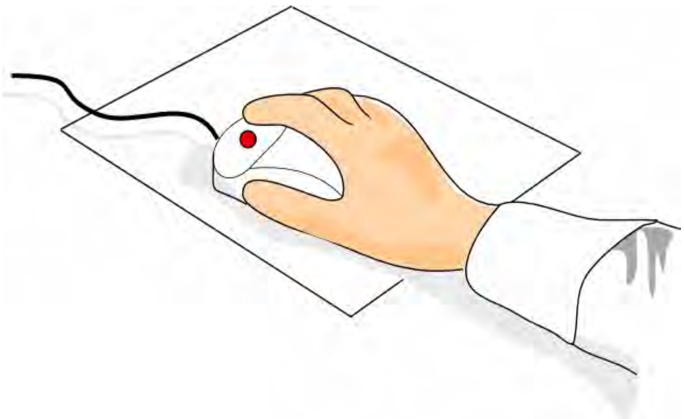

Figure 3.17: The hand reaction time test

Balance

Postural sway

For the balance tests, the subjects were instructed to remove their shoes and socks and postural sway was measured using a sway meter that measures displacements of the body at the waist level [27]. The device consisted of a 40cm-long rod attached to the subject at the waist level by a firm belt. A pen mounted vertically at the end of the rod posterior to the subject recorded the movements of the subject on a sheet of graph paper (with a millimetre square grid) which was fastened to the top of an adjustable height table (see Figure 3.18 below).

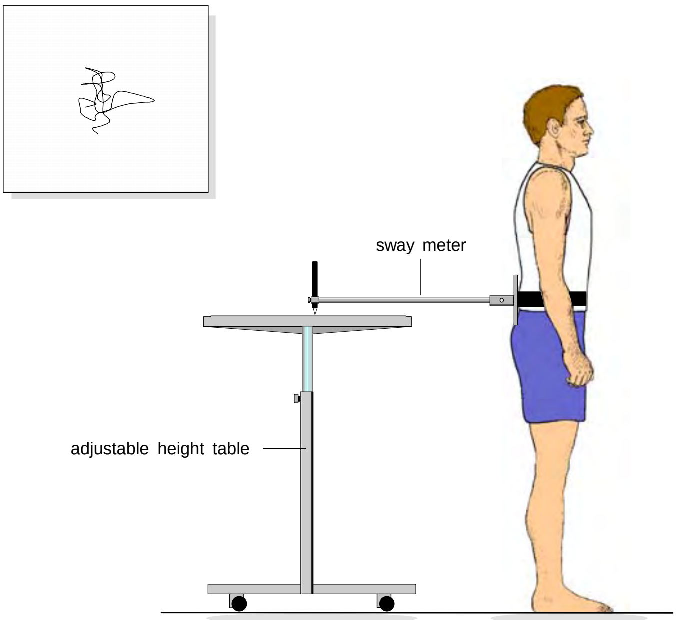

Figure 3.18: Postural sway assessment using the sway meter

The subject was instructed to stand with feet comfortably apart on a firm base and eyes focussed on a point at eye level at a distance of three metres. The subject stood in this position as motionless as possible for a period of 30 seconds The test procedure was then repeated under a further three conditions; standing on a firm base with the eyes closed; standing on high density foam rubber (70cm by 62cm by 15cm thick) with the eyes open; and standing on the foam rubber with the eyes closed. The foam was used to reduce proprioceptive input from the ankles so that the subject was required to rely on visual and/or vestibular cues to maintain a steady stance. Total sway (number of square millimetre squares traversed) in the 30 second test periods was recorded for the four test conditions.

Leaning balance

Leaning balance is measured with the coordinated stability test in which the swaymeter was positioned with the rod extending to the anterior of the subject. The coordinated stability race track was fastened to the top of an adjustable height table and positioned at waist height with the pen positioned in the centre of the sheet (see Figure 3.19).

The subject was required to trace the pen around the track aiming to stay inside the lines of the track. They were instructed to move their body in any direction to reach the extremes of the track, as long as they did not move their feet. The subject was given two attempts at the test and the best attempt was recorded as their score. The test was scored by giving each corner that an error was made on 5 points and each side that the pen went out of a score of 1 point.

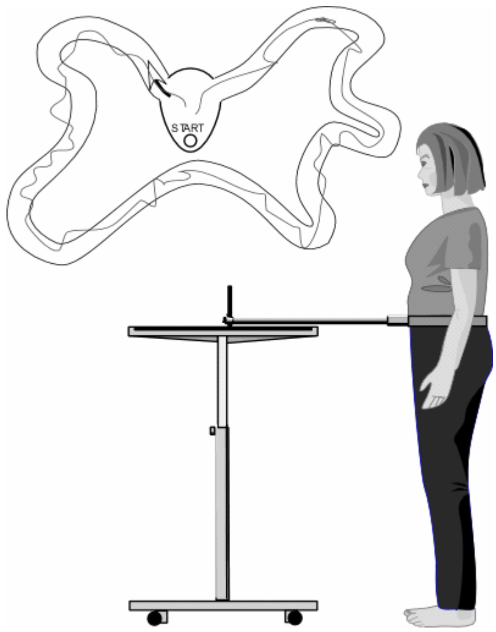

Figure 3.19: The co-ordinated stability test standing position and race track

Statistical analysis

The sensorimotor measures, balance measures and all of the functional tests, except for the pick up weight test, were continuous variables. For variables with skewed distributions, logs of the variables were analysed. Pearson correlation coefficients were computed to examine the relationship between each functional test and the PPA tests. Since the strength measures were highly correlated (r-values ranged from 0.57 to 0.81, $P<0.001$), a composite lower limb strength score was calculated by summing the scores. This measure was then normalized for body size using the formula: corrected strength = strength (N)/ [weight (kg) x height (m) / 2].

The PPA – functional test correlations were then used to guide which were the most appropriate physiological variables to be entered into the multiple regression equations for each functional test. If PPA variables within the vision, sensation, reaction time and balance domains were highly correlated, only one variable (that with the highest correlation with the functional test measure) was entered into each regression analysis. Beta weights and signs for the variables entered into the regression models were also examined to ensure they made meaningful contributions to test performance. The standardized beta weights provided give an indication of the relative importance of the various measures entered into the model in explaining the variance in functional test performance.

For the pick up weight test, which was a dichotomous variable, stepwise discriminant function analysis was used to determine which physiological variables predicted performance. All analyses were carried out using SPSS for Windows [164].

3.5 Results

All of the subjects completed the PPA tests. The subject numbers for the functional tests vary because some of the tests were introduced into the study protocol after subject recruitment had begun. Additionally, for those subjects who were unable to complete the functional tests, scores were allocated which were equivalent to three standard deviations below the mean. 12 people were unable to complete the sit to stand test with five repetitions, 10 were unable to complete the sit to stand test with one repetition and the alternate step test, 43 were unable to complete the near tandem stand, 51 were unable to complete the pick up test and one person was unable to complete the rod catch test. The means and standard deviations for performance in each of the tests are shown in Table 3.3.

Table 3.3: The means and standard deviations for performance in the physiological tests and the functional tests

Physiological tests	**N**	**Mean (SD)**
Visual acuity-high contrast (MAR)	620	1.3 (1.3)
Visual acuity-low contrast (MAR)	620	2.7 (2.1)
Edge contrast sensitivity (dB)	620	18.6 (2.5)
Depth perception (mm)	620	30.1 (38.1)
Proprioception (cm error)	620	2.1 (1.4)
Touch sensation ($\log_{10}$mg pressure)	620	4.4 (0.5)
Vibration sense (microns)	620	40.5 (26.8)
Knee extension strength (kg)	620	26.7 (12.4)
Knee flexion strength (kg)	620	15.0 (6.5)
Ankle dorsiflexion strength (kg)	620	6.8 (3.5)
Reaction time- foot (msec)	620	356 (64)
Reaction time- hand (msec)	620	277 (50)
Sway- eyes open, floor (area) ~	620	475 (506)
Sway- eyes closed, floor (area) ~	620	613 (649)
Sway- eyes open, foam (area) ~	620	1440 (1028)
Sway- eyes closed, foam (area) ~	620	3378 (2257)
Leaning balance test (errors)	620	9.0 (8.5)
Functional tests		
Sit to stand (5) test (sec)	607	13.1 (5.2)
Sit to stand (1) test (sec)	361	1.1 (0.7)
Rod catch test (msec)	361	261 (27)
Near tandem stand test (sec)	361	13.2 (11.9)
Pick up test- number able (%)	607	556 (92)
Half turn test (steps)	607	4.2 (1.3)
Alternate step test (sec)	574	11.1 (4.2)
Six metre walk test (sec)	607	6.1 (2.1)

~ Product of maximal anterior-posterior and lateral sway scores

Table 3.4 presents the results of the correlation calculations, showing that each of the functional measures correlated with many of the physiological measures. The significant correlation coefficients ranged from 0.09 to 0.48. The lower limb strength, reaction time and balance measures were significantly correlated with all of the functional tests. Additional significant correlations were also seen between the vision and peripheral sensation measures and some of the functional tests.

Table 3.4: Correlations between the functional tests and physiological measures (Pearson correlation coefficients unless specified otherwise)

Test variable	Sit to stand (5)	Sit to stand (1)	Rod catch	Near tandem stand	Pick up weight #	Half turn ~	Alternate step	Six metre walk
Visual acuity, high contrast	0.06	0.07	0.11 *	-0.03	-0.02	0.15 **	0.16 **	0.12 **
Visual acuity, low contrast	0.08	0.11 *	0.13 *	-0.10	-0.05	0.17 **	0.18 **	0.14 **
Edge contrast sensitivity	-0.19 **	-0.20 **	-0.20 **	0.20 **	0.06	-0.24 **	-0.23 **	-0.25 **
Depth perception	0.10 *	0.07	0.18 **	-0.10	-0.05	0.15 **	0.11 *	0.10 *
Proprioception	0.13 **	0.03	0.002	-0.04	-0.07	0.10 *	0.12 **	0.12 **
Touch sensation	0.14 **	0.08	0.004	-0.12 *	-0.04	0.05	0.11 **	0.05
Vibration sense	0.09 *	0.21 **	0.09	-0.09	0.07	0.10 *	0.13 **	0.09 *
Knee extension strength	-0.34 **	-0.27 **	-0.17 **	0.29 **	0.24 **	-0.25**	-0.41 **	-0.40 **
Knee flexion strength	-0.35 **	-0.27 **	-0.15 **	0.27 **	0.26 **	-0.22 **	-0.46 **	-0.44 **
Ankle dorsiflexion strength	-0.29 **	-0.23 **	-0.15 **	0.30 **	0.23 **	-0.14 **	-0.36 **	-0.35 **
Composite strength	-0.45 **	-0.39 **	-0.10	0.29 **	0.19 **	-0.25 **	-0.48 **	-0.41 **
Foot reaction time	0.28 **	0.19 **	0.25 **	-0.18 **	-0.22 **	0.14 **	0.38 **	0.32 **
Hand reaction time	0.23 **	0.15 **	0.23 **	-0.12 *	-0.18 **	0.13 **	0.34 **	0.26 **
Sway, eyes open, floor	0.13 **	0.16 **	0.11 *	-0.16 **	-0.02	0.06	0.15 **	0.17 **
Sway, eyes closed, floor	0.18 **	0.19 **	0.05	-0.17 **	-0.06	0.10 *	0.20 **	0.23 **
Sway, eyes open, foam	0.25 **	0.15 **	0.18 **	-0.21 **	-0.13 **	0.17 **	0.32 **	0.30 **
Sway, eyes closed, foam	0.17 **	0.23 **	0.08	-0.15 **	-0.10 *	0.14 **	0.27 **	0.25 **
Leaning balance	0.29 **	0.26 **	0.15 **	-0.29 **	-0.21 **	0.37 **	0.42 **	0.38 **

* $p<0.05$, ** $p<0.01$;
# point-serial correlation
~ Spearman rank order correlation

The results of the multiple regression analyses are shown in Tables 3.5 to 3.11.

Table 3.5: Multiple regression model for the sit to stand test with five repetitions

Predictor Variables	Beta weights	p value	Adjusted r^2
Composite strength #	-0.40	0.000	0.27
Sway (foam, eyes open) (area) ~	0.14	0.000	
Touch sensation (log_{10}mg pressure)	0.12	0.001	
Foot reaction time (msec)	0.11	0.003	
Edge contrast sensitivity (dB)	-0.07	0.044	

~ Product of maximal anterior-posterior and lateral sway scores

sum strength (N)/ [weight (kg) x height (m) / 2]

As can be seen in Table 3.5, the multiple regression result for the sit to stand test with five repetitions shows that the composite lower limb strength measure was the most important factor in explaining the variance in test performance amongst the subjects and it had a beta weight that was more than twice the beta weights of the other four variables in the equation. The other predictors in the model were postural sway measured while standing on a compliant surface, touch sensation, foot-press reaction time, and edge contrast sensitivity. Overall, these five variables explained 27% of the variance in the sit to stand test results

Table 3.6: Multiple regression model for the sit to stand test with one repetition

Predictor Variables	Beta weights	p value	Adjusted r^2
Composite strength #	-0.35	0.000	0.22
Sway (foam, eyes closed) ~	0.18	0.000	
Vibration sense (microns)	0.15	0.001	
Edge contrast sensitivity (dB)	-0.13	0.008	

~ Product of maximal anterior-posterior and lateral sway scores

sum strength (N)/ [weight (kg) x height (m) / 2]

The variables that were found to be significant predictors of the sit to stand test with one repetition, were similar but not identical to those of the five repetition test (see Table 3.6). Again, the composite lower limb strength measure was the strongest predictor with a Beta weight of -0.35, which was twice as high as the Beta weights of the other three variables. There was also a measure of postural sway, however in the one repetition protocol it was the sway test performed while standing on the compliant surface with the eyes closed which was found to be a significant, independent predictor of performance. The other significant variables were the vibration sense measure and the edge contrast sensitivity test, which shows that performance in this test is influenced not only by lower limb strength and balance but also by lower limb sensation and vision. Overall this model explained 22 % of the variance in test performance.

Table 3.7: Multiple regression model for the rod catch test

Predictor Variables	Beta weights	p value	Adjusted r^2
Reaction time foot (msec)	0.19	0.000	0.09
Depth perception (mm)	0.15	0.003	
Sway (foam, eyes open) ~	0.12	0.026	

~ Product of maximal anterior-posterior and lateral sway scores

Predictably, a measure of reaction time had the highest beta weight in the rod catch test model, followed by depth perception and postural sway on a compliant surface (see Table 3.7). This model explained 9% of the variance in rod catch test times.

Table 3.8: Multiple regression model for the near tandem stand test

Predictor Variables	Beta weights	p value	Adjusted r^2
Composite strength #	0.20	0.000	0.13
Leaning balance (errors)	-0.15	0.009	
Sway (foam, eyes open) ~	-0.14	0.007	
Touch sensation (log_{10}mg pressure)	-0.10	0.046	

~ Product of maximal anterior-posterior and lateral sway scores

sum strength (N)/ [weight (kg) x height (m) / 2]

For the near tandem stand test, the four physiological variables which were predictive of performance, in order of importance were composite lower limb strength, leaning balance, postural sway while standing on a compliant surface with eyes open and touch sensation. This model only explained 13% of the variance in test performance, as shown in Table 3.8.

Table 3.9: Multiple regression model for the half turn test

Predictor Variables	Beta weights	p value	Adjusted r2
Leaning balance (errors)	0.24	0.000	0.15
Composite strength #	-0.13	0.001	
Edge contrast sensitivity (dB)	-0.13	0.001	
Proprioception (cm error)	0.08	0.033	

sum strength (N)/ [weight (kg) x height (m) / 2]

For the half turn test, the variable that explained the most variance in test performance was the measure of leaning balance, followed by the composite lower limb strength measure, the edge contrast sensitivity vision test and lower limb proprioception (see Table 3.9). Like the near tandem stand test model, the amount of variance in test performance explained by this model was only small (15%), indicating that other factors not included in this analysis may be associated with performance in the test.

Table 3.10: Multiple regression model for the alternate step test

Predictor Variables	Beta weights	p value	Adjusted r^2
Composite strength #	-0.35	0.000	0.38
Foot reaction time (msec)	0.18	0.000	
Leaning balance (errors)	0.17	0.000	
Sway (foam, eyes open) ~	0.16	0.000	
Vibration sense (microns)	0.11	0.001	
Edge contrast sensitivity (dB)	-0.07	0.047	

~ Product of maximal anterior-posterior and lateral sway scores

sum strength (N)/ [weight (kg) x height (m) / 2]

The model derived for the alternate step test included the composite measure of lower limb strength as the most important factor, with a much higher Beta weight than the other variables. The other predictors were foot-press reaction time, leaning balance, postural sway while standing on a compliant surface with eyes open, vibration sense and edge contrast sensitivity. This model explained 38% of the variance in alternate step test times as is shown in Table 3.10, which is a higher overall percentage explained than in all of the other functional test models.

Table 3.11: Multiple regression model for the six metre walk test

Predictor Variables	Beta weights	p value	Adjusted r^2
Composite strength #	-0.27	0.000	0.28
Sway (foam, eyes open) ~	0.16	0.000	
Leaning balance (errors)	0.15	0.000	
Foot reaction time (msec)	0.13	0.001	
Edge contrast sensitivity (dB)	-0.11	0.003	
Proprioception (cm error)	0.08	0.028	

~ Product of maximal anterior-posterior and lateral sway scores

sum strength (N)/ [weight (kg) x height (m) / 2]

The predictor variables in the six metre walk test regression equation are shown in Table 3.11. As can be seen, the six-variable model is almost the same as the alternate step test model, with the composite strength measure exhibiting the highest Beta weight. There are also two measures of balance (the leaning balance test and postural sway on a compliant surface) as well as the measures of foot-press reaction time and edge contrast sensitivity. The inclusion of proprioception here rather than vibration sense is the only difference in the components of the two models. This model explained 28% of the variance in performance of the six metre walk test.

The variables included in the discriminant function analysis for the pick up weight test were the composite lower limb strength measure and the test of leaning balance. The two-variable model had a Wilk's lambda of 0.95 (p=0.000) and correctly classified 62% of the subjects as able or not able to perform the test.

3.6 Discussion

The results of the multiple regression analyses show that the functional mobility measures included in this study are composite measures of the PPA measures and therefore are likely to be associated with risk of falling in older people. The amount of variance explained by the regression models was quite low though, ranging from 9% to 38%, which shows that other factors not measured here would also affect test performance.

Lower limb strength was the strongest predictor of performance in six out of the eight functional mobility tests, including the sit to stand tests with one and five repetitions, near tandem stand test, alternate step test, six metre walk test and the pick up weight test. This result illustrates the importance of adequate lower limb strength in the performance of tasks that are related to activities of daily living, ambulation and postural transfers and is supported by the work of other authors [165, 166, 167].

The sit to stand test with five repetitions, the alternate step test and the six metre walk test had similar regression models. Performance in these tests was associated with a combination of lower limb strength, postural stability, reaction time, peripheral sensation and vision, illustrating the multiple physiological components that good performance in these tests relies upon. The regression models for these tests also resulted in the highest overall percentage of variance explained, ranging from 27% for the sit to stand test with five repetitions to 38% for the alternate step test.

Performance in the sit to stand test with one repetition was also influenced by lower limb strength, postural stability, peripheral sensation and vision. Unlike the five repetition test model however, there was no reaction time test included as a predictor, which suggests that this is a postural transfer task rather than a measure of speed and co-ordination.

Since the sit to stand models only explained 27% and 22% of the variance in test performances, it is clear that other factors not included in this analysis may have a significant effect on individual performance in the tests, as has been demonstrated previously [71]. Nevertheless, the models developed with this small pool of variables show that the tests are not merely proxy measures of lower limb strength [76, 77], but are composite measures of functioning that are influenced by a variety of factors in addition to lower limb strength.

Performance in the near tandem stand test was also influenced by measures of lower limb strength, balance and peripheral sensation however the model that resulted from this analysis shows that much of the variance in test performance is left unaccounted for. Therefore, other factors not measured in this study are likely to influence performance in this test. Nonetheless, the results obtained here are in accordance with those obtained by Lord and colleagues [156] who found that the near tandem stand test performed with the eyes closed was associated with performance in tests of knee extension strength, proprioception and with age.

Performance in the rod catch test was predominantly influenced by foot reaction time, which is to be expected, but it was also influenced by depth perception and performance in one of the sway tests- while standing on the foam with eyes open. Furthermore, these three variables only explained 9% of the variance in test performance, indicating that like the other tests, there are other factors that have an affect on performance in the test which have not been included in this analysis. From these results and the fact that the correlations of the rod catch test with two measures of simple reaction time were only weakly significant (correlations of r=0.25 and r=0.23, $P<0.01$, for the foot reaction time test and the hand reaction time test respectively), it could be concluded that the rod catch test is not a good substitute for an equipment dependent test.

In this analysis the half turn test was predominantly associated with a measure of dynamic balance but was also influenced by performance in tests of lower limb strength, vision and proprioception. In accordance with the results for the near tandem stand test and the rod catch test, the overall amount of variance explained by this regression model was quite small (15%).

The pick up weight test model included two physiological measures as independent predictors of performance- lower limb strength measure and leaning balance. This model was able to predict test performance with an accuracy of 62%, showing that since the test is a measure of strength and balance, poor performance in it is likely to be associated with an increased risk of falling.

The alternate step test model was able to explain the greatest amount of variance in test scores with the six predictor variables explaining 38% of the difference in scores from one subject to another. The relatively small values for variance explained by each of the other models outlined here illustrates the complex nature of these tests and implies that in this sample of older people, other physiological, psychological and/or health related factors are likely to also play a role in how well a person is able to perform each test. Such factors may include vestibular sense [168] and ankle joint range of motion [169], as well as psychological and health factors such as fear of falling and the presence of lower limb arthritis, which have been found to be important in the performance of other functional tasks [71, 85, 170].

When these results are considered as a whole, it would appear that the test which is the most useful as a measure of lower limb strength, balance and mobility is the alternate step test since the physiological variables selected in its regression model were able to explain the most variance in test performance times. The next most useful test would be the six metre walk test since its regression model also explained a substantial amount of test performance variance and its most important predictor variables were measures of lower limb strength, balance and reaction time. These findings however need to be considered in conjunction with the other validity study results to determine the best measures for inclusion in a clinical falls risk assessment.

In conclusion, this study has helped to determine which physiological factors from the PPA are associated with performance in some commonly used functional mobility measures that have previously been used to assess disability and frailty in older people. This was a factor for consideration in regards to the selection of tests for the clinical falls risk assessment, since it was crucial to ascertain whether the tests that had been selected for possible inclusion were actually measuring factors that were relevant to a person’s risk of falling. The next stage in the development of the clinical falls risk assessment was to determine the test-retest reliability of these functional measures, as described in chapter four.

Chapter Four

Test-retest reliability study

4.0 Aim

The aim of the reliability study was to determine the test-retest reliability of the tests described in chapter three for measuring lower limb strength, reaction time, balance, co-ordination and mobility.

4.1 Background- Test-retest reliability

Reliability can be defined as the consistency of measurements or of an individual's performance on a test [1] or the absence of measurement error [2]. Test-retest reliability is an important consideration when tests are being selected to assess physical performance and change in function over time. The reliability of a test is a reflection of how dependable the measures are as a true reflection of the actual physical status of the individual being assessed. This is particularly important if the tests are to be used to determine a change in function over time, for example this may be an improvement in performance as a result of an intervention or deterioration in performance due to a disease state or due to the ageing process.

4.2 Methods

Subjects

The subjects recruited for the reliability study were selected from the 620 subjects who were participating in the randomised controlled trial described in chapter three (page 74). 30 people were recruited for the reliability study (10 men, 20 women) and they ranged in age from 75 to

90 years (mean= 80.1, SD= 4.0). The prevalence of self-reported medical conditions and limitations in activities of daily living (ADL) in the reliability study sample are shown in Table 4.1. Informed consent was obtained from all subjects prior to participation, and approval for the study was given by the Human Studies Ethics Committee at the University of New South Wales.

Table 4.1: Prevalence of major medical conditions and ADL limitations obtained from self-report in the reliability study sample (n=30)

Medical conditions	**Number of subjects (%)**
Diabetes	4 (13.3)
Stroke	2 (6.7)
Arthritis	13 (43.3)
Incontinence	2 (6.7)
Depression	3 (10)
4+ medications	20 (66.7)
Fall in past 12 months	11 (36.7)
Use of a walking aid	2 (6.7)
Activities of daily living	
Difficulty with shopping	2 (6.7)
Difficulty with housework	5 (16.7)
Difficulty with cooking	2 (6.7)

Assessment measures

The tests included in the reliability study were the sit to stand test with five repetitions, the sit to stand test with one repetition, the rod catch test, the near tandem stand test, the pick up weight test, the half turn test, the alternate step test and the six metre walk test. These tests are described in chapter three (page 62) and were chosen to encompass the major neuro-physiological domains that contribute to balance (lower limb strength, reaction time, coordination), as well as more global measures of stability and mobility.

The additional tests of vision and peripheral sensation that were selected for possible inclusion in the clinical falls risk assessment have had their test-retest reliability assessed previously in two studies [159], (the second study is unpublished). The latter study involved 31 community-dwelling people (13 men and 18 women) aged 76 to 87 years (mean=80.8 years, SD=3.1) and performance in the tests was measured on two occasions, two weeks apart. The visual acuity test was shown to have an intra-class correlation coefficient ($ICC_{3,1}$) of 0.89 (95% confidence interval (CI) 0.78-0.95) and co-efficient of variation (CoV) of 20.3% and the tactile sensitivity had an $ICC_{3,1}$ of 0.56 (95% CI 0.09- 0.79), and a CoV of 4.9%. This indicates good reliability for the vision test and moderate reliability for the sensation test. The moderate reliability obtained for the sensation test has previously been shown to be as good as clinical assessments of sensation are likely to achieve [171] since there are other factors that are known to affect subject performance, such as the psychological factors of subject motivation, distraction and fatigue.

Test –retest assessment protocol

Two research assistants with three years of testing experience administered the initial tests and the retests (approximately two weeks later), ensuring that the same examiner assessed the same subject on both occasions. The tests took approximately 15 minutes to administer and were carried out at the Falls Assessment Clinic at Royal North Shore Hospital, Sydney.

Statistical analysis

All statistics were performed using the SPSS Release 14.0 for Windows statistics software [164]. The reliability of the continuously scored functional measures was determined by the use of the intra-class correlation coefficient (ICC) with the (3, 1) model, which provides an estimate of the agreement between the initial test and retest scores [172]. The coefficient of variation (CV) was computed for each of the test comparisons to express the variation between trials as a percentage. Variables with skewed distributions were $\log_{10}$ transformed prior to analysis. To interpret the ICC values, benchmarks suggested by Fleiss [173] were used. These state that a measure with an ICC of greater than 0.75 has excellent reliability, ICCs between 0.40-0.75 have fair-to-good reliability and ICC less than 0.40 have poor reliability.

Test-retest reliability for the pick up test was determined using the kappa (κ) statistic. To interpret the kappa ratings, benchmarks suggested by Landis and Koch [174] were used. These state that a rating of greater than 0.81 is almost perfect, a rating between 0.61-0.80 is substantial, a rating of between 0.41-0.60 is moderate, a rating of between 0.21-0.40 is fair and a rating of between 0.0-0.20 is slight and less than zero is poor.

4.3 Results

The median time between the measurement sessions was 14 days (IQR= 8). The means and standard deviations for each of the continuously-scored variables at each testing session are shown in Table 4.2, as well as the results of the test-retest reliability calculations for each of the variables. The ICCs were excellent for the sit to stand test with five repetitions and the alternate step test, good for the half turn test, six metre walk test and rod catch test, and fair for the sit to stand test with one repetition and the near tandem stand test.

Coefficients of variation were small for the sit to stand test with five repetitions, the alternate step test, the rod catch test and the six metre walk test (5.2%, 2.7%, 3.4% and 4.7% respectively) indicating that little variation in the measurements occurred between the tests and retests. The coefficients of variation for the half turn test, the sit to stand test with one repetition and the near tandem stand test were higher (10.8%, 54.9% and 27.1% respectively). This indicates that there was moderate variation in the measurements from one session to the next. For the pick up test, all subjects were able to perform the test on both test occasions. While this indicated perfect agreement, the kappa statistic could not be computed.

Table 4.2: Means (SD) of test performance for each continuous variable across the two measurement sessions

Test variable	Test	Retest	ICC (95% CI)	CV
Sit to stand, one (s)	0.8 (0.3)	0.8 (0.3)	0.54 (0.23- 0.75)	54.9
Sit to stand, five (s)	10.5 (2.9)	10.5 (2.5)	0.89 (0.79- 0.95)	5.2
Rod catch (ms)	236.7 (21.9)	236.6 (23.5)	0.69 (0.44- 0.84)	3.4
Near tandem stand (s)	9.3 (9.3)	11.0 (8.8)	0.54 (0.22- 0.75)	27.1
Alternate step (s)	9.5 (2.2)	9.0 (1.9)	0.78 (0.59- 0.89)	2.7
Half turn (steps)	4.3 (1.0)	3.9 (0.9)	0.75 (0.54- 0.87)	10.8
Six metre walk (s)	5.2 (0.7)	5.2 (0.9)	0.74 (0.52- 0.87)	4.7

4.4 Discussion

The objective of this study was to determine the test-retest reliability of several measures of lower limb strength, reaction time, balance, coordination and mobility. The results demonstrate that most of these tests have good test-retest reliability and are therefore useful for assessing physical functioning in older people. The tests which displayed the best reliability were the sit to stand test with five repetitions, the alternate step test, the half turn test and the six metre walk test. Good reliability is essential for a screening test to provide confidence the test is providing a dependable, stable measure, and a true reflection of the actual physical construct being assessed. Good reliability in a test of physical function also allows for the test to be used to assess performance over time, for example, when monitoring progress as a result of intervention programs, since change in performance can be assumed to be a reflection of change in individual ability, not simply measurement error.

These results compare well with other studies that have examined the reliability of tests which are used to assess physical functioning in older people [80, 175]. Sherrington et al included the six metre walk test in their reliability study of functional measures of gait, strength and balance for assessing people after hip fracture. Six metre walk time was found to be the most reliable of all the measures with a very high ICC value of 0.97. The sit to stand test with five repetitions was also included in the Sherrington et al study and had a similar ICC value to that found in this study.

Three of the tests included in the present reliability study exhibited reliability values in the fair to good range. These were the near tandem stand test, the rod catch test and the sit to stand test with one repetition. Reduced reliability scores may be due not only to variable performance by the subjects, but also because of difficulties in standardising and administering the tests. For example, while easier to perform than the tandem stand test, some subjects still had difficulty standing in the correct position in the near tandem stand test. In consequence, they may have adopted slightly different stances from one testing session to the next, leading to variability in the scores obtained. Also, when administering this test, the assessor needs to allow the subject sufficient time to gain their balance in the near tandem position before the eyes are closed and the test is commenced. If time is not given consistently for the subject to prepare themselves for the test, this too could lead to variability in test performance. A related test – the tandem gait test - has previously been assessed for reliability in a study involving community-dwelling older people [66]. This study showed that this test had only poor intra-rater reliability. The authors suggested that the low reliability may have been due to a greater range of potential strategies adopted to perform the task, leading to a greater variability in performance from one session to the next.

Tester error seems likely to have contributed to the fair reliability score obtained for the sit to stand test with one repetition. Most subjects in the reliability study completed this test in less than one second, with the scores ranging from 0.4 seconds to 1.8 seconds. Such short periods required the tester to be very accurate with the timing of the start and finish of the test, and it is likely that tester errors occurred. The test may be more reliable in a frailer population with slow sit to stand times. Additionally, the small range of scores obtained for this test may have added to the poor ICC obtained.

The only moderate reliability results for the near tandem stand test and the rod catch test may also be a reflection of the novel nature of these tests as they are not closely related to any activities of daily living or everyday tasks. For this reason, it may take some time for individuals to become familiar with the requirements of these tests and devise the best strategies for performing them to the best of their ability, hence more practice prior to performance may be needed if the results gained are to be a true reflection of ability. For the near tandem stand test in particular, there is the need to integrate incoming information from several sources in order to maintain stability and to work out the most advantageous standing position with regard to how the body weight should be distributed and which foot should be positioned in the forward position.

In conclusion, it appears that the requirement for the tests to be simple to carry out and require minimal equipment did not compromise reliability, as all tests had acceptable reliability. However, acceptable reliability is only one factor in the selection of tests to be included in a clinical falls risk assessment. A second major factor: good externally validity is also required for measures to be included in the assessment tool. The ability of the above tests to predict falls is examined in the next two chapters.

Chapter Five

Functional balance and mobility tests - External validity studies

5.0 Aims

The first aim of the first external validity study was to determine whether the functional balance and mobility assessment measures described in chapter three provided good discrimination between older multiple and non-multiple fallers in a sample of older people at an increased risk of falling. The second aim was to determine cut-points that optimise the predictive accuracy of each test when scored dichotomously. The third aim was to confirm the predictive accuracy of the dichotomised measures in a randomly selected sample of older people.

5.1 Background

The ability of tests in fall screens and fall risk assessment tools to predict falls would appear to be an obvious criterion, yet as described in chapter two, few screens and assessment tools could claim to have an evidence base to support their external validity in this regard. Chapters five and six assess the ability of the proposed tests for predicting multiple fallers. The focus on the identification of people at risk of multiple falls rather than single falls is based on several factors. Multiple falls are associated with increased disability, functional impairment and death in older people [176] compared with single falls, which are less predictable [32] and may be more likely to occur due to chance or because of extrinsic factors [177]. Multiple falls are also an indicator of possible underlying chronic medical conditions and/ or underlying physiological impairment and are also associated with an increased risk of institutionalization [178].

5.2 Methods

Subjects

The subjects included in the initial external validity study comprised a subgroup of those people included in the construct validity study described on page 74 of chapter three. The sample included the subjects from the randomised controlled trail who were randomised to the control groups, totalling 400 people (137 men, 263 women) with an age range of 74 to 98 years (mean= 80.4, SD= 4.5). The age and sex distribution of the sample is presented in Table 5.1. Only these subjects were included because control subjects were not exposed to preventive interventions which may have reduced their risk of falling. The prevalence of self-reported medical conditions and limitations in activities of daily living (ADL) in the sample for this validity study are shown in Table 5.2.

Table 5.1: The age and sex distribution [number (%)] of the subjects in the initial external validity study

Age-group (years)	**Men**	**Women**	**Total**
74-79	71 (52)	129 (49)	200 (51)
80-84	37 (27)	89 (34)	126 (30)
85-89	21 (15)	37 (14)	58 (15)
90+	8 (6)	8 (3)	16 (4)
Total	137 (34)	263 (66)	400 (100)
Mean age (SD)	80.4 (4.8)	80.4 (4.4)	80.4 (4.5)

Table 5.2: Prevalence of major medical conditions and limitations in activities of daily living in the subjects in the initial external validity study

Medical variables	**Number of subjects (%)**
Diabetes	28 (7.0)
Stroke	30 (7.5)
Arthritis	162 (40.5)
Incontinence	60 (15.0)
Depression	42 (10.5)
Take 4 or more medications	203 (50.8)
Had a fall in past 12 months	172 (43.0)
Use of a walking aid	71 (17.8)
Activities of daily living	
Unable to do shopping	9 (2.3)
Unable to do housework	23 (5.8)
Unable to do cooking	9 (2.3)

The subjects included in the second, confirmatory external validity study were 301 people (117 men, 184 women) aged 70 years and over (mean=77.2 years, SD=4.9) who were living in private households in the eastern suburbs of the Sydney metropolitan area. These people were randomly selected from the state electoral roll and potential subjects were excluded from the study if they had minimal English language skills, were blind, or had a Mini Mental State Examination (MMSE) score of less than 24 [179]. The age and sex distribution of this sample is presented in Table 5.3. The prevalence of self-reported medical conditions and limitations in activities of daily living (ADL) in this sample is shown in Table 5.4.

Table 5.3: The age and sex distribution [number (%)] of the subjects in the second external validity study

Age-group (years)	Men	Women	Total
70-74	34 (29)	62 (34)	96 (32)
75-79	43 (37)	72 (39)	115 (38)
80-84	30 (26)	37 (20)	67 (22)
85 +	10 (9)	13 (7)	23 (8)
Total	117 (39)	184 (61)	301(100.0)
Mean age (SD)	77.9 (4.78)	76.95 (4.96)	77.20 (4.89)

Table 5.4: Prevalence of major medical conditions and limitations in activities of daily living in the subjects in the second external validity study

Medical variables	Number of subjects (%)
Diabetes	16 (5.3)
Stroke	9 (3.0)
Arthritis	174 (57.8)
Incontinence	63 (20.9)
Take 4 or more medications	197 (65.4)
Had a fall in past 12 months	111 (36.9)
Use of a walking aid	21 (7.0)
Activities of daily living	
Unable to do shopping	28 (9.3)
Unable to do housework	17 (5.6)
Unable to do cooking	10 (3.3)

Assessment measures

The assessment measures comprised the functional balance and mobility tests described in chapter three (page 62) as measures considered for possible inclusion in the clinical falls risk assessment. They include the following: the sit to stand test with one and five repetitions, the rod catch test, the near tandem stand test, the pick up weight test, the half turn test, the alternate step test and the timed six metre walk test. These tests were chosen because they are commonly used to assess mobility and function in older people and several of them have been associated with the prediction of falls in previous research [32, 65, 82].

Falls surveillance

Falls experienced by the study subjects for a period of one year were measured prospectively, using monthly fall calendars (see the Appendix). The definition of a fall used for this study and throughout this thesis is "unintentionally coming to the ground or some lower level and other than as a consequence of sustaining a violent blow, loss of consciousness, sudden onset of paralysis as in a stroke or an epileptic seizure" [180]. The fall calendars were given to each subject at their initial visit to the study site and included reply paid envelopes. When a fall occurred the subject recorded the date on the calendar and was instructed to phone the research team to enable them to collect specific details about the fall. The subjects mailed the calendars to the research team at the end of each month. Subjects who failed to return their calendars on time were telephoned to remind them to do so.

Statistical analysis

For the continuously scored tests, independent samples *t*-tests were used to determine if there were significant differences in performance between multiple fallers and non-multiple fallers. Variables with skewed distributions were $\log_{10}$ transformed in the t-test analyses. For the pick up test, which was a dichotomously scored variable, where subjects were rated as "able" or "unable" to perform the test, the relative risk statistic was used to determine if there were significant differences between the faller groups.

The relationships among the functional mobility tests were also examined with principal components analysis with varimax rotation. This procedure was used to explore underlying patterns in the data to elucidate whether the tests represent a single construct or multiple, independent ones.

Receiver-operated characteristics (ROC) curves were inspected to determine cut-points for each continuously-scaled test that best discriminated between those who did and did not suffer multiple falls. In determining the cut-points, a protocol of aiming for the specificity and sensitivity to be above 0.5 (or 50%) was employed, in addition to the need for the associated relative risk values to be statistically significant. This balance between good specificity and sensitivity was deemed important for a falls risk assessment so that interventions can be targeted to the people who are most likely to gain benefit. A protocol which attempted to maximise the sensitivity of the tests at the expense of their specificity would result in the risk of incorrect targeting of many people who are not actually at risk of falling with intervention strategies which are potentially expensive in economic terms and inappropriate to the needs of these individuals. Additionally, the test performance cut-points were selected so that they reflected practical levels of measurement, i.e. selecting integer cut-points, particularly for the timed tests measured in seconds. Relative risk values were calculated for all of the comparisons to determine the strength and significance of the associations found. P values of <0.05 in the univariate analysis were considered statistically significant. Finally, a χ^2 test for trend was used to assess for any increased risk of falls with impairments in two or more tests. Analyses were performed using SPSS for Windows [164] and Epi Info™ [181] statistical software.

5.3 Results- first external validity study

362 subjects (90%) completed the 12-month follow-up – of the 38 subjects who were non-completers, 4 died, 4 moved from the study area, 14 reported ill health and 16 withdrew consent. At the completion of the twelve month follow-up period, 183 (51%) subjects had reported no falls, 99 (27%) had reported one fall and 80 (22%) had reported two or more falls. Hence, for comparison of performance in the assessment measures, 80 subjects were multiple fallers (2 or more falls) and 282 subjects were non-multiple fallers (1 or less falls).

The means and standard deviations for performance in the tests by the 362 subjects, stratified by sex are shown in Table 5.5. Missing data are due to the inclusion of some tests after the study had commenced. Missing data (n=18) were imputed for the alternate step test. Significant differences in performance between men and women were found for the near tandem stand test and for the pick up test, where men performed better than women.

Table 5.5: Comparison of performance in the functional tests between men and women

Variable	Male		Female	
	N	Mean (SD)	N	Mean (SD)
Sit to stand five test	128	13.13 (5.58)	234	12.98 (4.98)
Sit to stand one test	66	1.06 (0.49)	149	1.04 (0.61)
Rod catch test	66	257.17 (27.00)	149	261.45 (26.03)
Near tandem stand test	66	16.46 (12.86)	149	12.46 (11.51) *
Pick up weight test †	128	127 (99)	234	206 (88) **
Half turn test	128	4.25 (1.46)	234	4.17 (1.24)
Alternate step test	128	10.89 (3.61)	234	11.22 (4.21)
Six metre walk test	128	5.88 (1.78)	234	6.02 (1.56)

*=p<0.05, **=p<0.01

†Number (%) able to complete test

The results of the *t*-test analyses are shown in Table 5.6. The findings showed that multiple fallers performed significantly worse than non-multiple fallers in three of the functional mobility tests: the sit to stand test with five repetitions, the alternate step test and the six metre walk test. There was a trend indicating the multiple fallers performed worse in the half turn test and in the near tandem stand test, but little indication that the two groups differed in the sit to stand test with one repetition and in the rod catch test.

The Chi-square test results revealed no significant difference between the multiple faller and non-multiple faller groups in the performance of the pick up weight test (χ^2=1.5, df =1, p=0.23).

Table 5.6: *T*-test comparing performance in the assessment measures between multiple fallers and non-multiple fallers

Variable	**Multiple Fallers**		**Non-multiple fallers**		
	N	Mean (SD)	N	Mean (SD)	p-value
Sit to stand five test	80	14.81 (6.23)	282	12.53 (4.75)	0.000
Sit to stand one test	45	1.12 (0.56)	170	1.03 (0.58)	0.247
Rod catch test	45	262.56 (25.00)	170	259.50 (26.73)	0.490
Near tandem stand test	45	11.43 (11.78)	170	14.29 (12.09)	0.158
Half turn test #	80	4.50 (1.65)	282	4.11 (1.20)	0.080
Alternate step test	80	12.30 (4.44)	282	10.77 (3.81)	0.002
Six metre walk test	80	6.44 (1.83)	282	5.84 (1.56)	0.003

Mann-Whitney U test

The significant associations between the test measures when coded as continuous variables were also evident when the tests were dichotomised using cut-points. The results of the ROC curve inspections are shown in Table 5.7. For the prediction of multiple falls, the sensitivity values ranged from 11% to 77% and the specificity values ranged from 28% to 93%. Several of the measures had fair sensitivity and specificity, but none had excellent predictive accuracy. The tests with the highest combination of sensitivity and specificity were the sit to stand test with five repetitions, with a performance cut-point of 12 seconds (66% and 55% respectively) and the alternate step test with a performance cut-point of 10 seconds (70% and 55% respectively). The half turn test had the highest sensitivity (77%) at a performance cut-point of 4 steps, but its specificity was low (28%), making it less accurate at detecting people who are not at risk of falling. The sit to stand test with one repetition, the rod catch test and the pick up test were not useful in discriminating between the faller groups.

Table 5.7: ROC curve analysis results for predicting multiple fallers

Variable	Cut-point	Sensitivity (%)	Specificity (%)	Area under curve	RR (95% CI)
Sit to stand five test	≥12sec	66	55	0.64	1.99 (1.31-3.01)
Sit to stand one test	≥1sec	40	65	0.56	1.17 (0.69-1.99)
Rod catch test	≥260msec	56	47	0.53	1.07 (0.63-1.80)
Near tandem test	<10sec	64	49	0.57	1.55 (0.89-2.68)
Half turn test	≥4 steps	77	28	0.59	1.28 (0.80-2.05)
Alternate step test	≥10sec	70	55	0.65	2.28 (1.48-3.51)
Six metre walk test	≥6sec	50	69	0.62	1.76 (1.20-2.58)
Pick up weight test	unable	11	93	0.52	1.46 (0.82-2.60)

The principal components analysis identified three factors amongst the functional mobility and balance tests that had an eigenvalue of 0.9 or greater. The absolute value loadings of the tests ranged from 0.46 to 0.99 and the three factors combined explained 72% of the variance of the mobility test measures. The three underlying factors were mobility/dynamic balance, reaction time and standing balance and the individual loadings for each variable for the three factors are shown in Table 5.8.

Table 5.8: The results of the principal components factor analysis (absolute value loadings)

Variable	Mobility/dynamic balance	Reaction time	Standing balance
Sit to stand five test	0.837	0.066	0.067
Sit to stand one test	0.800	-0.028	0.120
Rod catch test	0.093	0.990	0.026
Near tandem stand test	-0.071	-0.018	-0.936
Half turn test	0.471	0.027	0.459
Alternate step test	0.859	0.086	0.065
Six metre walk test	0.729	0.176	0.296

As indicated from a χ^2 test for trend analysis ($p<0.001$), poor performance in two of the three mobility tests which varied significantly between the faller groups increased the risk of multiple falls more than poor performance in one test alone, as illustrated in Figure 5.1. However there was no additional increased risk of multiple falls for poor performance in all three tests.

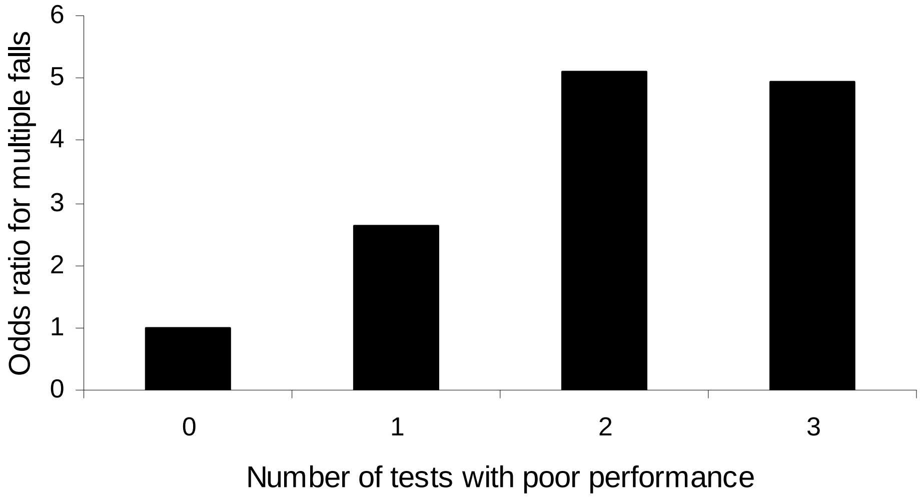

Figure 5.1: Relationship between the number of mobility tests with poor performance and the Odds Ratio for multiple falls

5.4 Results- second external validity study

The results of the first external validity study were used to guide the selection of tests for the second confirmatory external study. The tests chosen were the sit to stand test with five repetitions, the near tandem stand test and the alternate step test, since these were shown to discriminate between faller groups. The six metre walk test was included in the initial validity study in case it proved to be the most useful of the mobility tests in predicting falls. As it eventuated, this test proved to be no better than the other three significant tests. As this test requires a six metre long walkway, which is not always possible in a clinical setting, it was considered to not have sufficient advantages to make it a necessary inclusion in an assessment tool. This test was therefore not further evaluated in the second validity study.

For the follow-up external validity study, 287 subjects (95%) completed the 12-month follow-up – of the 14 subjects who were non-completers, 3 died, 1 reported ill health and 10 withdrew consent. At the completion of the twelve month follow-up period, 168 (59%) subjects had reported no falls, 67 (23%) had reported one fall and 52 (18%) had reported two or more falls. Hence, for comparison of performance in the assessment measures, 52 subjects were multiple fallers (2 or more falls) and 235 subjects were non-multiple fallers (1 or less falls).

The performance cut-points that were devised in the initial validity study were again used in this study. Table 5.9 shows the sensitivity, specificity, area under the ROC curves and relative risk values for each of the three measures. As is evident, all but one of the sensitivity and specificity values were above 50% and the relative risk values ranged from 1.65 to 1.83, indicating a significantly increased risk of multiple falls associated with poor performance in the tests. These results are comparable to the results of the first external validity study.

Table 5.9: Ability of test measures to predict multiple fallers in the follow-up study

Variable	**Cut-point**	**Sensitivity (%)**	**Specificity (%)**	**Area under curve**	**RR (95% CI)**
Sit to stand five test	≥12sec	64	52	0.59	1.68 (1.00-2.84)
Near tandem test	<10sec	46	69	0.57	1.65 (1.02-2.69)
Alternate step test	≥10sec	52	66	0.59	1.83 (1.11-2.99)

5.5 Discussion

The aim of the first external validity study was to determine the ability of several assessment measures to discriminate between multiple fallers and non-multiple fallers, as determined by a prospective follow-up of a large sample of older community-dwelling people. It was found that three continuously scored functional balance and mobility tests discriminated significantly between the faller groups. These tests were the sit to stand test with five repetitions, the alternate step test and the six metre walk test.

Further investigation of the tests involved devising cut-points to determine the critical level of performance which could dichotomize test performance and optimise the sensitivity and specificity of the tests for predicting fall status. This procedure was carried out in order to simplify the test protocols and the interpretation of results and thereby increase the suitability of the tests for use in clinical settings. This analysis revealed that the three significant tests could predict multiple fallers with RR values of 1.8 and above.

These results were confirmed by the results of the follow-up study which examined the accuracy of the tests, when dichotomised with the performance cut-points, to predict multiple falls in a randomly selected sample of older people.

These results are in accordance with previous research which has shown an association between the mobility tests (or modified versions) and risk of falling. The alternate step test is a modified version of the stool stepping task that is included in the Berg Balance Scale (BBS), which was originally scored on a scale from 0 to 4 relating to the ease with which the subject can undertake the task within a 20 second period. The BBS has been used to predict falls risk in older people in a variety of settings [65, 104] and in the study by Chiu et al, the stool stepping task along with two other mobility and balance measures from the BBS, was identified as a significant predictor of falls in a small group of community-dwelling older people and hence recommended for inclusion in a falls risk assessment.

A similar test to the alternate step test was included in a study by Nevitt et al [32] which investigated risk factors for recurrent falls. The rapid step-ups test assessed the number of steps onto a 23cm block that could be performed within 10 seconds. The results of the study showed that a criterion of less than 3 steps in the 10 second test period was a significant predictor of multiple falls (RR=1.7, 95% CI= 1.2-2.3), which is a somewhat slower level of performance than was found in the current study. However, the step used for the alternate step test was 19 centimetres high, i.e. 4 cm lower than the step used by Nevitt and colleagues. Additionally 33% of the people in the Nevitt et al study were multiple fallers, which is substantially higher than the 22% of people included in the current study and may explain some of the differences in physical abilities found and the different performance cut-points determined by the studies.

The results for the sit to stand test with five repetitions support the findings of previous studies [32, 70], which have found that this test is a significant predictor of falls in older community-dwelling people. A performance cut-point in this test for predicting people who had a balance deficit was determined previously by Whitney et al [78], however these authors found that a somewhat slower performance cut-point of 14.2 seconds produced the optimal sensitivity and specificity for predicting a balance disorder in subjects aged older than 60 years. This result may reflect the different outcome measures studied - one being recurrent falls and the other being balance disorders.

The six metre walk test had sensitivity and specificity values of 50% and 69% respectively at the performance cut-point of six seconds in the initial study. This yielded a relative risk value of 1.8, indicating a substantial risk of recurrent falls associated with slow performance in this test. Previous work has shown that slow walking speed is a risk factor for falls [82, 83] and average walking speeds for older people have been calculated to be between 0.9 and 1.1 metres per second [182, 183]. The performance cut-point of more than six seconds to complete a six metre walk, as was found in this study to predict multiple falls, is in accordance with some previous studies of gait speed in older people. However other studies have found much slower gait speeds to be predictive of falls risk. One such study found gait speed of less than 0.6 metres/ second to be the critical level for predicting people at risk of multiple falls (RR=1.6, 95% CI: 1.2-2.2) [32]. The six metre walk test proved to be no better than the other three significant tests in the initial validity study for predicting fallers. Further it did not appear to provide unique discriminatory ability as this test loaded on the same factor as the alternate step test and the sit to stand tests. For these reasons and because the six metre walk test is less feasible than the other tests for some clinical settings, it was not further evaluated in the second validity study.

Poor performance in the near tandem stand test has previously been associated with an increased risk of falling in older people [156]. In the initial validity study, while performance in the test displayed good sensitivity for predicting multiple fallers, the specificity of the test was low (49%) and the resultant relative risk score, while indicating a 55% increased risk of multiple falls as a consequence of poor test performance, approached but did not reach statistical significance (95% CI= 0.9-2.7). Because of these results, the tests ability to discriminate between faller groups was further evaluated in the second validity study, which showed that the near tandem stand test significantly discriminated between multiple fallers and non-multiple fallers with sensitivity and specificity values of 46% and 69% respectively and a resultant relative risk score of 1.65 (95% CI= 1.02-2.69). Hence, this test provides a simple measure of lateral stability - a factor that has been shown to be crucial for maintaining balance and preventing sideways falls [37, 156, 184] and is also able to discriminate between faller groups.

The remaining tests provided low predictive accuracy. The non-significant result for the turn test contrasts to the findings of Nevitt and colleagues [32], who found that people who took five or more steps to complete a 180 degree turn were significantly more likely to be multiple fallers than people who used fewer steps to turn (RR=1.9, 95% CI: 1.2-3.2). These researchers also found slow performance in the sit to stand test with one repetition to be predictive of multiple falls, with a performance cut-point of ≥2 seconds associated with a significant relative risk score of 2.4 (95% CI= 1.8-3.2). Similarly, Chiu and colleagues [104] identified a task similar to the pick up test as being one of three tasks from the Berg Balance Scale that were significant predictors of falls in a retrospective study of a small sample of community-dwelling older people.

Reaction time was one of the three factors identified by the factor analysis, the other two factors being mobility/dynamic balance and standing balance. The individual measure which encompassed the reaction time factor was the rod catch test. However, despite the importance of this test in explaining the variance in functional mobility and balance scores, it was not a significant predictor of falls and hence was omitted from further inclusion in the falls risk assessment.

In the initial study the pick up test had very high specificity (>90%) for predicting multiple fallers, but low sensitivity (10%) and the RR scores for these did not reach statistical significance. This result reflects that 92% of the subjects were able to complete the pick up test, which led to it being a poor predictor of fall status. Clearly, the majority of this community-dwelling population did not find this test to be particularly challenging.

In summary, these two validity studies identified three functional balance and mobility measures that discriminated between multiple fallers and non-multiple fallers in two samples of older community-dwelling people. The initial study also identified performance cut-points for the tests which optimised their sensitivity and specificity for predicting multiple fallers and simplified the interpretation of test results to enable them to be used easily as part of a clinical falls risk assessment. The validity of additional measures for possible inclusion in the clinical falls risk assessment is outlined in chapter six which follows.

Chapter Six

Clinical falls risk assessment tool - External validity study

6.0 Aim

The aim of this external validity study was to evaluate the ability of all of the proposed clinical falls risk assessment measures to discriminate between older multiple fallers and non-multiple fallers in a individual patient data meta-analysis involving four samples of older community-dwelling people. A further aim was to devise an overall risk score based on the cumulative number of risk factors identified by the clinical falls risk assessment.

6.1 Background

The design of this study allowed for the pooling of data from four cohorts so that the predictive validity of the falls risk assessment measures could be assessed in subjects with a range of ages and functional abilities.

6.2 Methods

Subjects

The study comprised data from four prospective cohort studies which recruited community-based people to examine falls risk factors. Study group one comprised the 362 subjects who were included in the initial external validity study which is described in chapter five (page 116). This study will be referred to here as the Northern Sydney Falls Prevention (NSFP) study.

Study group two comprised 329 women, aged 65 years and over (mean=73.2 years, SD=6.1)) who were participants in the Randwick Falls and Fractures Study [31], which will be referred to here as the RFF study. These people were living in private households in the Randwick local government area of Sydney and were randomly selected from the electoral roll between the years of 1988 and 1991. The falls risk assessment was carried out at Prince of Wales Hospital and the exclusion criteria for participation were: not living in the dwelling at the time of the study or having minimal English language skills.

The third subject group was 148 men and women aged 63 years and over (mean=76.4 years, SD=5.1) who resided in the eastern suburbs of Sydney. This study aimed to investigate visual risk factors for falls [152] and will be referred to here as the Visual Risk factor for Falls (VRF) study. Half of the sample were living independently in the community and were randomly selected from the electoral roll. The remaining subjects were recruited from a retirement village in the study area. Exclusions to participation in the study included poor English language skills and cognitive impairment as evidenced by a Short Portable Mental Status Questionnaire (SPMSQ) score of ≤ 7 [162]. Testing took place at Prince of Wales Medical Research Institute for the community sample and at a common room within the retirement village.

The fourth study group comprised 287 men and women aged 70 years and over (mean=77.1 years, SD=4.9) who were living in private households in the eastern suburbs of the Sydney metropolitan area who took part in the Prevention of Older People’s Injuries (POPI) Study. These people were randomly selected from the state electoral roll and potential subjects were excluded from the study if they had minimal English language skills, were blind, or had a

Mini Mental State Examination (MMSE) score of less than 24 [179]. The falls risk assessment testing took place at Prince of Wales Medical Research Institute.

The total sample for this validity analysis consisted of 1126 subjects aged 63-98 years (mean=76.90 years, SD= 5.86). 291 (26%) of the subjects were men, 835 were women. The prevalence of self-reported medical conditions and limitations in activities of daily living (ADL) in the study sample are shown in Table 6.1, as well as the age and sex distributions of the samples.

Table 6.1: Characteristics of the four cohorts- demographics, prevalence of major medical conditions and limitations in activities of daily living (ADLs)

Demographic variables	**Sample 1 (NSFP)** N=362	**Sample 2 (RFF)** N=329	**Sample 3 (VRF)** N=148	**Sample 4 (POPI)** N=287	**Total sample** N=1126
Age [mean (SD)]	80.3 (4.5)	73.2 (6.1)	76.4 (5.1)	77.1 (4.9)	76.90 (5.86)
Female- number (%)	234 (65)	329 (100)	92 (62)	180 (63)	835 (74)
Medical variables, number (%)					
Diabetes	26 (7)	14 (6)	6 (4)	16 (6)	62 (6)
Stroke	27 (8)	9 (4)	10 (7)	9 (3)	55 (5)
Arthritis	144 (40)	89 (29)	73 (49)	168 (60)	474 (43)
Use of a walking aid	65 (18)	#	23 (16)	20 (7)	108 (14)
Limitations in ADLs, number (%)					
Difficulty with shopping	7 (2)	33 (10)	12 (8)	25 (9)	77 (7)
Difficulty with housework	19 (5)	35 (11)	12 (16)	16 (6)	82 (8)
Difficulty with cooking	7 (2)	13 (4)	5 (3)	3 (1)	28 (3)

#variable not measured in this study

Assessment measures

The measures included in the analysis included: previous falls, total number of medications, psychoactive medications, low contrast visual acuity, touch sensation, the sit to stand test with five repetitions, the alternate step test and the near tandem stand test. These measures are described in chapter three (pages 62-72).

Falls surveillance

Falls experienced by the subjects for a period of one year were measured prospectively, using monthly fall calendars. For the NSFP study, the VRF study and the POPI study, the calendars were given to each subject at their initial assessment and included a reply paid mailing option. When a fall occurred, the subject marked the date on the calendar and the calendars were returned to the research team at the end of each month. If they were not returned on time, further contact was made by telephone interview. For the RFF study, the fall questionnaire and reminder protocol were similar to the other studies however the calendars were mailed out and completed by the study participants every two months.

Statistical analysis

Since the assessment measures were tested with the same protocol in each study, the data from the four cohort studies were combined for all analyses. Subjects were classified as either a multiple faller (2 or more falls) or a non-multiple faller through analysis of the prospectively measured falls data.

For the continuously scored tests (visual acuity, touch sensation, sit to stand test and alternate step test), independent samples *t*-tests were used to determine if there were significant differences in performance between multiple fallers and non-multiple fallers. Variables with skewed distributions were $\log_{10}$ transformed in the t-test analyses. For the markedly non-normally distributed variables (psychoactive and total medication use and previous falls) Mann-Whitney U tests were used to assess differences between the faller groups. For the near tandem stand test, which was scored dichotomously (able/ unable to stand for 10 seconds) the Chi-square statistic was used to assess differences between the faller groups.

Receiver-operated characteristics (ROC) curves were inspected to determine cut-points for each continuously-scaled test that best discriminated between those who did and did not suffer multiple falls. In determining the cut-points, a protocol of aiming for the specificity and sensitivity to be above 0.5 (or 50%) was employed, since good specificity as well as good sensitivity is important for a falls risk assessment so that interventions can be targeted to the people who are most likely to gain benefit. Additionally, the cut-points were selected so that they reflected practical levels of measurement, i.e. selecting integer cut-points, particularly for the timed tests measured in seconds. Relative risk values were also calculated for all of the comparisons to determine the strength and significance of the associations found. P values of <0.05 in the univariate analysis were considered statistically significant.

The data from the 362 subjects in the NSFP study were used to formulate an overall fall risk score. This study was the only one of the four studies which included all of the falls risk assessment measures. Since there was missing data for the near tandem stand test (n=147), due to its inclusion in the study protocol after the study had commenced, these data were imputed in order to maximise the number of complete sets of data available for the formulation of the risk table. ROC curves were inspected to determine the critical number of risk factors that corresponded to the greatest discrimination between multiple and non-multiple fallers. Finally, a Chi-square for linear trend analysis was undertaken to determine the risk of multiple falls that resulted from increasing numbers of risk factors identified in the falls risk assessment. *P* values of <0.05 in the univariate analysis were considered statistically significant. All analyses were performed using SPSS for Windows [164] and Epi Info [181] statistical software.

6.3 Results

Of the total sample, 633 people (56%) reported no falls, 263 people (23%) reported one fall and 230 people (21%) reported 2 or more falls. Hence for the purposes of the analyses, 230 people were classified as multiple fallers (57 men, 173 women) compared with 896 non-multiple fallers (234 men, 662 women).

Comparison of performance between faller groups

Table 6.2 shows the results of the analyses which compared performance in the continuously scored assessment measures between multiple fallers and non-multiple fallers. The findings show that multiple fallers performed significantly worse than non-multiple fallers in all of the measures. Missing data for the visual acuity test are due to the non-inclusion of data for this test from the POPI study since vision was measured with a different protocol (right and left eyes measured separately). There was also missing data for the touch sensation test because this test was not included in the VRF study and because the data for this test from the POPI study was deemed unreliable since there were errors made with the administration of the test.

Table 6.2: *T*-test comparing performance in the continuously scored assessment measures between multiple fallers and non-multiple fallers

Variable	**Multiple Fallers**		**Non-multiple fallers**		
	N	Mean (SD)	N	Mean (SD)	p-value
Falls in past year	230	1.21 (1.26)	896	0.47 (0.80)	0.000 #
Total medications	230	4.50 (2.52)	896	3.53 (2.42)	0.000 #
Psychoactive meds	230	0.27 (0.58)	896	0.14 (0.39)	0.000 #
Visual acuity test *	178	3.40 (3.45)	661	2.46 (1.40)	0.000
Touch sensation test **	145	4.40 (0.56)	545	4.23 (0.48)	0.002
Alternate step test (s)	130	11.87 (4.41)	487	10.37 (3.66)	0.001
Sit to stand test (s)	130	14.65 (6.20)	487	12.49 (4.40)	0.000
Tandem stand test(s) (number [%] who completed test)	132	62 (47)	517	335 (65)	0.000

Mann-Whitney U test

*Minimum angle resolvable (MAR) measured in minutes of arc

** Lg_{10} mg pressure

The results of the ROC curve inspections are shown in Table 6.3. For the prediction of multiple falls, the sensitivity values ranged from 21% to 65% and the specificity values ranged from 53% to 88%. Several of the measures had fair sensitivity and specificity, but none had excellent predictive accuracy. The measures with the highest combination of sensitivity and specificity were falls in the past year, with a performance cut-point of one or more falls (61% and 67% respectively) and the alternate step test with a performance cut-point of 10 seconds (63% and 60% respectively). All of the tests displayed significant relative risk values, ranging from 1.41 for the touch sensation test to 2.50 for the measure of previous falls, indicating that poor performance in the assessment measures was associated with a significantly increased risk of future multiple falls.

Table 6.3: Test performance criteria for predicting multiple fallers

Variable	N	Cut-point	Sensitivity (%)	Specificity (%)	Area under curve	RR (95% CI)
Falls in past year	1126	≥1	61	67	0.66	2.50 (1.97-3.17)
Total medications	1126	≥4	65	54	0.63	1.90 (1.48-2.42)
Psychoactive meds	1126	≥1	21	88	0.58	1.68 (1.28-2.19)
Visual acuity test (MAR)	839	≥ 2.3	56	58	0.59	1.59 (1.22-2.06)
Touch sensation test (lg10 mg pressure)	690	>4.29	52	59	0.57	1.42 (1.06-1.89)
Alternate step test (s)	617	≥10	63	60	0.62	2.08 (1.51-2.87)
Sit to stand test (s)	617	≥12	65	53	0.62	1.84 (1.33-2.54)
Tandem stand test(s)	649	<10	53	65	0.59	1.78 (1.31-2.41)

Overall falls risk score

The total number of risk factors present in NSFP study cohort ranged from 0 to 8, with a median of 3, which was a total obtained by 16% of the sample. Only 11 people (3%) displayed no risk factors and only 6 people (1.7%) displayed all 8 risk factors. The majority of the sample had either two (21.5%), three (16%) or four (19.3%) risk factors.

For predicting multiple fallers, the ROC curve showed that at the cut-point of ≥4 risk factors (evident in 48% of the sample) the sensitivity for prediction was 76% and the specificity was 60% (p=0.00) and the corresponding relative risk value was 3.47 (95% CI: 2.16-5.56).

Table 6.4 shows the Odds Ratios corresponding to the number of risk factors identified. The table shows a significant increased odds of multiple falls with the presence of two or three risk factors and a further increased odds as the number of risk factors present exceeds this, up to a an odds ratio of 8.6 with the presence of 5 or more risk factors. The Chi-square statistic for this analysis was 32.65 ($p<0.001$).

Table 6.4: The Odds Ratio scores which correspond to the number of risk factors identified by the clinical fall risk assessment

Number of risk factors	Odds Ratio
0-1	1.0
2-3	1.69
4	4.72
5 or more	8.58

6.4 Discussion

The aim of the validity study outlined in this chapter was to determine the ability of the eight measures that comprised the clinical falls risk assessment to predict falls in a large sample of older community-dwelling people. Multiple fallers performed significantly worse than non-multiple fallers in all of the assessment measures. The relative risk (RR) values ranged from 1.4 to 2.5, indicating that the presence of a risk factor resulted in at least a 40% increase in the risk of being a multiple faller (poor touch sensation), to a risk of 150% indicated by the occurrence of at least one fall in the previous year. The sensitivity and specificity scores for all of the tests were greater than 50%, with the exception of the sensitivity score for the psychoactive medications variable.

The result obtained for the measure of previous falls is in accordance with the work of several authors who have found that people who have experienced falls in the past have a significantly increased risk of future falls [3, 4, 50]. Similarly, the results obtained for the predictive ability of the two medications variables support previous work which has found an increased risk of falling in people who take multiple medications [6, 43] and an increased risk of falling with the taking of psychoactive medications [3, 6, 9].

The tactile sensitivity test, at a cut-point of greater than 4.29 $\log_{10}$ 0.1mg (corresponding to a mid range monofilament of an aesthesiometer set) had a sensitivity of 52% and specificity of 59% for predicting multiple falls. This corresponded to a significant relative risk value of 1.4. This result is in accordance with previous research which has shown an association between reduced peripheral sensation and risk of falling in older people [28, 39].

The results obtained for the three functional mobility and balance measures represent the predictive ability of the tests when the data used to assess them separately in chapter five is pooled. This allowed for robust sensitivity, specificity and relative risk values of the tests to be devised using a large sample of older people.

In addition to establishing the validity of the individual risk assessment measures, this study was used to develop an overall fall risk score based on the sum of risk factors identified by the assessment. The results showed that the fall risk increases with the presence of two risk factors, which indicated a 1.7 times increased risk of future falls compared to someone with one or zero risk factors. The risk of future falls was cumulative up to 5 or more risk factors where the odds of multiple falls reached 8.6. This illustrates the multifactorial nature of falls and supports the findings of previous authors [5, 59] who have found a cumulative increase in the risk of falling as the number of risk factors identified increases. A cumulative risk emphasises the need for remedial interventions to be put in place and thus serves as a useful adjunct to the individual fall risk factor information.

The final stage in the development of the clinical falls risk assessment was to ascertain the feasibility of the assessment when used in clinical settings by various health practitioners. This is outlined in chapter seven.

Chapter Seven

The feasibility study

7.0 Aim

The aim of the feasibility study was to determine the acceptability and utility of the falls risk assessment in the care of elderly patients in a range of clinical settings.

7.1 Background

As outlined in chapter two, there are many factors cited by clinicians as barriers to them initiating preventive activities with their patients. These include factors such as lack of time, lack of knowledge and resources and poor financial reward. These issues had to be considered when this risk assessment was being developed. It was considered important that the acceptability of the risk assessment to clinicians was paramount in order to ensure that the assessment would be used routinely in clinical practice.

7.2 Refinement of assessment tool

Prior to introducing the falls risk assessment to the clinicians, certain steps were undertaken to ensure that it was user-friendly, compact and portable and quick to administer within the confines of a clinical setting. The risk assessment was given a name, so that it could be discriminated from other falls risk assessments and would be easily identified as a comprehensive validated assessment. The name "QuickScreen" was chosen as it conveyed the idea of a fast screening assessment. The name also related to the "Fallscreen" falls risk assessment (the commercial name of the Physiological Profile Assessment) [117] from which it "evolved".

In addition, part of the refinement process involved finalising the components of the assessment tool to ensure that it was as quick and as easy to use as possible. The final components of the QuickScreen clinical falls risk assessment, as described in the instructions section of the assessment kit are included below.

Previous falls

The first risk factor that is assessed as part of the QuickScreen assessment is history of falls. This is done by way of the question: "Have you had any falls in the past twelve months".

Medication usage

Two measures regarding medication usage are included in the assessment. Firstly there is an assessment regarding polypharmacy, where the clinician is required to determine if the patient currently takes four or more medications (excluding vitamins and minerals). Secondly, there is an assessment of whether the patient takes any psychoactive medications.

Low contrast visual acuity test

Visual acuity is measured using a chart with low-contrast (10%) letters (similar to a Snellen scale).

<u>Procedure</u>

The patient is seated at a distance of three metres from the visual acuity chart which is mounted on the wall at eye height, under a good source of light. They wear the glasses they would normally wear for distance vision. Ask them to read out the lowest line of letters they can read easily on the chart. Point to the next line down and ask them to read out the letters. Continue to move down the chart until they cannot see the next line or until they score all errors. The lowest line read and the number of letters correct is recorded.

Score

The patient must be able to correctly identify all of the letters on line 10 (fifth line down) to pass the test.

Tactile sensitivity

This test involves the use of a pressure aesthesiometer placed on the lateral malleolus of the ankle of the dominant side. The patient is seated and barefoot.

Procedure

The patient is asked to keep their eyes closed throughout the test and indicate to the tester (by saying "yes") if they can feel the monofilament being placed on the lateral malleolus of the ankle. The filament is applied for 1 second and pressure applied until it bends. If the filament "flicks off" the trial should be repeated. One practice trial and three test trials are given.

Score

The patient must be able to feel at least two of the three test trials to pass the test.

The near tandem stand test

This is a measure of balance and ankle strength and involves testing whether the patient can stand with feet in a near tandem position for a period of 10 seconds with their eyes closed. Equipment required is a stopwatch and 2.5cm square cardboard template for foot positioning.

Procedure

Demonstrate the position of the feet first and explain that the test involves standing in this position for 10 seconds with eyes closed. Allow the patient to choose which foot they place in the forward position for the test. Use the square template to separate the feet laterally by 2.5cm and the heel of the front foot 2.5cm anterior to the great toe of the back foot (see diagram at left). If the patient is unsteady, support them as they assume the test position. When they are in position and steady, remove your support and ask them to close their eyes and balance in that position without moving their feet, until you say “stop”. Start timing from when they close their eyes. If a time of 5 seconds or less is obtained, a second trial is allowed and the better result is used as the final score.

Score

The patient must be able to balance in this position for at least 10 seconds to pass the test.

The alternate step test

This is a measure of strength, balance and co-ordination. Equipment required includes a stopwatch and 18cm high step.

Procedure

Demonstrate the task first: place the right foot onto the step, supporting the body weight with the left, then place the right foot back on the ground and place the left foot onto the step. Emphasise that the whole foot should be placed onto the step, but the body weight remains supported by the grounded leg (i.e. the patient is not required to actually step onto the step). The task is to be completed as quickly as possible, 4 repetitions per foot, alternating right and left. Start timing from when the first foot is lifted off the ground and count aloud each of the 8 foot taps.

Score

The patient must complete the task in less than 10 seconds to pass the test.

The sit to stand test with five repetitions

This test involves timing how long it takes the patient to stand up and sit down five times from a seated position. Equipment required includes a 45cm high, straight-backed chair and a stopwatch.

Procedure

The patient is asked to perform the movements as quickly as possible with both arms folded in front. Demonstrate the test procedure first, emphasising the need to stand all of the way up until both knees and hips are fully extended and to sit all of the way down for each repetition. Ask the patient to place their feet directly below their knees at the start of the test and keep their arms folded across their chest for the duration of the test. Ask if they are ready and signal the start of the test by saying, "Go". Start timing from when the shoulders first move forwards and count aloud each repetition. Stop timing when they have completed five repetitions and are seated.

Safety: Make sure the chair doesn't move back when the patient sits down by steadying it against a wall or with your hand.

Score

The patient must complete the task in less than 12 seconds to pass the test.

The assessment form

The next stage in refining the components of the QuickScreen clinical falls risk assessment was to develop an assessment form which would allow the clinicians to carry out the tests in a timely manner with an easy method of scoring performance in each test and the ability to also record the need for any interventions. To do this a one page assessment form was developed (see Figure 7.1), which allows the assessor to score each risk factor by simply circling “yes” or “no” to signify the presence or absence of each one. A column down the right side of the page was included as a space for the clinician to record any actions that are required as a result of the assessment of each factor. For example, if the patient is found to fail the vision test, the clinician may recommend that they need to have an eye examination and vision assessment with their ophthalmologist or optometrist and this recommendation would be documented in the “action” column as a record for future follow-up. Similarly, if the patient is unable to pass the balance/ strength tests, they may be referred to a physiotherapist for an appropriate exercise program and this too would be noted in the “action” column.

At the bottom of the assessment form is the risk score table which allows the clinician to sum the number of risk factors present in the patient (by adding up the number of times “yes” is circled in the second column) and use this number to calculate the corresponding risk score which represents the risk increase presented by the risk factors identified, compared to someone who has one or zero risk factors. The advantage of this is that the assessment allows for an overall score to be calculated which quantifies the risk and assists the patient to appreciate the level of their risk. Furthermore, if the score is high, it reinforces the need for remedial action to be taken. It also means that a numerical comparison can be made if the assessment is repeated in the future and it is a simple way of identifying if interventions are having an effect.

***QuickScreen* Clinical Falls Risk Assessment**

Patient:____________________________ Date:______________

MEASURE	**RISK FACTOR PRESENT?** (please circle)	**ACTION**
Previous Falls		
One/more in previous year	Yes/No	
Medications		
Four or more (excluding vitamins)	Yes/No	
Any psychotropic	Yes/No	

Recommendation: Review current medications

Vision		
Visual acuity test Unable to see all of line 10	Yes/No	

Recommendation: Give vision information sheet. Examine for glaucoma, cataracts and suitability of spectacles. Refer if necessary.

Peripheral Sensation		
Tactile sensitivity test Unable to feel 2 out of 3 trials	Yes/No	

Recommendation: Give sensation loss information sheet. Check for diabetes.

Strength/ Reaction Time/ Balance		
Near tandem stand test Unable to stand for 10 secs	Yes/No	
Alternate step test Unable to complete in 10 secs	Yes/No	
Sit to stand test Unable to complete in 12 secs	Yes/No	

Recommendation: Give strength/balance information sheet. Refer to community exercise class or home exercise program if appropriate to individual level of functioning.

Number of risk factors	**0-1**	**2-3**	**4**	**5 +**
Total risk increase	**1**	**1.7**	**4.7**	**8.6**

Total Risk Increase: The patient has _______ times the risk of falling as someone with one or fewer risk factors.

Figure 7.1: The QuickScreen assessment form

The education sheets

Three one page education sheets are also included in the QuickScreen assessment kit as take-home information for the patients if they are found to have the relevant risk factors. There is one education sheet pertaining to poor vision as a risk factor for falls, one pertaining to peripheral sensation loss as a risk factor for falls and one pertaining to poor leg strength, balance and co-ordination as risk factors for falls (see the Appendix). As well as outlining why the particular factor places a person at risk of falls, the sheets include strategies for compensating for impairments in the individual risk factors or for improving the factors where possible. Additionally, if a patient is unable to complete any of the functional mobility and balance tests (i.e. the sit to stand test, the alternate step test and the near tandem stand test), the QuickScreen kit also includes a home exercise booklet which can be given to the patient to complete at home. Alternatively, if the clinician believes that this is not appropriate for the individual, due for example to the need for supervised exercise, the kit also includes information that can be given to the patient about community exercise groups which are run in the local area and which are designed for older people to participate in. The education sheets are written in a manner that is easy to understand for non-medically trained people and since they are included in the QuickScreen assessment kit, they can be given to the patient immediately after they have been assessed by the clinician, which allows for the quick and easy instigation of intervention strategies for the risk factors identified.

Packaging of the screening kit

The QuickScreen assessment is packaged in an A4-sized plastic folder. The front inside cover contains a plastic slot which securely holds the touch sensation monofilament to ensure that it is not damaged over time. There is also a plastic sleeve at the front of the folder which contains the stopwatch and near-tandem stand template. Plastic sleeves inserted into the folder hold the instructions for carrying out the tests, the assessment forms and the education sheets to be given to patients.

The kit is packaged in this way because it keeps the testing equipment and the assessment forms together with the education sheets. This makes storage of the assessment components easy and there is less risk that parts of the assessment kit will be misplaced. It was also believed that by having the education sheets in the same place as the assessment forms, there would be a greater likelihood that they would be given to the patients immediately after the assessment is carried out.

7.3 Feasibility study methods

Subjects

40 clinicians from the Sydney metropolitan area, the New South Wales Southern Highlands and the Canberra region took part in the study. There were 25 General Practitioners (GPs), 12 physiotherapists and 3 practice nurses. The participants were recruited through contact with health promotion officers at the respective divisions of general practice and through contact with chapters of the Australian Physiotherapy Association.

Each clinician was provided with a QuickScreen assessment kit and the assessment procedure was explained to them at a face-to-face appointment at their workplace. This allowed for a practical demonstration of the assessment components and gave the clinician the opportunity to ask questions. Most of the equipment needed to carry out the tests was included in the QuickScreen kit however the clinicians were required to supply a standard height chair and low stool. The clinicians were instructed to use the QuickScreen with as many of their patients as possible who were aged 65 years and older (with a target of at least 20 patients), during a 3 to 4 month period. It was left up to the discretion of the clinician to decide for whom an assessment may be beneficial. The researcher made telephone contact with all of the clinicians every 2 to 3 weeks to monitor compliance and to answer any questions they had.

Follow-up evaluation

After a period of between 3 and 4 months, the participating clinicians were sent an evaluation questionnaire (see the Appendix). The aim of the questionnaire was to gain feedback about the strengths and weaknesses of the QuickScreen assessment and to gather suggestions for future modifications. A further aim of the questionnaire was to determine if the clinicians found that the assessment assisted with the management of their elderly patients and if they would continue to use it in the future.

7.4 Results

Of the 40 clinicians who initially agreed to take part in the study, 8 (one physiotherapist and seven GPs) did not undertake any assessments, claiming a lack of time. This left data from 32 clinicians for analysis (18 GPs, 3 practice nurses and 11 physiotherapists), the results of which are summarised in Table 7.1. Overall, the clinicians assessed an average of 9 patients (SD: 5.7, Range: 1 to 30) before the evaluation questionnaire was completed. The responses showed that most clinicians (72%) found that the QuickScreen assessment took 10 minutes or less to carry out, making it feasible for completion in a normal consultation time.

Table 7.1: The results of the clinician evaluation survey

	GPs (n=18)	**Physios (n=11)**	**Nurses (n=3)**	**Total (n=32)**
Assessments completed (Mean, SD)	10.0 (6.33)	7.0 (4.56)	11.0 (5.29)	9.1 (5.74)
Assessment took ≤10 mins to carry out [n (%)]	14 (78)	7 (64)	2 (67)	23 (71.9)
Ratings of each assessment measure				
Previous falls				
Not at all useful	0	0	0	0
Somewhat useful	4 (22)	2 (18)	0	6 (18.8)
Useful	8 (44)	4 (36)	2 (67)	14 (43.7)
Very useful	6 (33)	5 (46)	1 (33)	12 (37.5)
Medications				
Not at all useful	3 (17)	0	0	3 (9.4)
Somewhat useful	1 (6)	1 (9)	1 (33)	3 (9.4)
Useful	9 (50)	5 (46)	1 (33)	15 (46.8)
Very useful	5 (28)	5 (46)	1 (33)	11 (34.4)
Visual acuity				
Not at all useful	0	0	0	0
Somewhat useful	2 (11)	0	0	2 (6.3)
Useful	8 (44)	5 (46)	1 (33)	14 (43.7)
Very useful	8 (44)	6 (55)	2 (67)	16 (50.0)
Tactile sensitivity				
Not at all useful	2 (11)	0	0	2 (6.3)
Somewhat useful	5 (28)	0	0	5 (15.6)
Useful	6 (33)	8 (73)	1 (33)	15 (46.9)
Very useful	5 (28)	3 (27)	2 (67)	10 (31.2)
Near tandem stand test				
Not at all useful	0	0	0	0
Somewhat useful	0	0	0	0
Useful	11 (61)	6 (55)	0	17 (53.1)
Very useful	7 (39)	5 (46)	3 (100)	15 (46.9)
Alternate step test				
Not at all useful	0	0	0	0
Somewhat useful	1 (6)	2 (18)	0	3 (9.4)
Useful	10 (56)	2 (18)	0	12 (37.5)
Very useful	7 (39)	7 (64)	3 (100)	17 (53.1)
Sit to stand test				
Not at all useful	0	0	0	0
Somewhat useful	1 (6)	1 (9)	0	2 (6.3)
Useful	10 (56)	3 (27)	1 (33)	14 (43.7)
Very useful	7 (39)	7 (64)	2 (67)	16 (50.0)

The questionnaire included a 4-point rating scale for each assessment measure to gauge the usefulness of the individual measures, ranging from "not at all useful" to "very useful". As can be seen in Table 7.1, the assessment measure which received the best rating overall was the near tandem stand test, which all of the clinicians rated as useful or very useful. The assessment measure which received the lowest, yet still a mostly positive rating was the tactile sensitivity test with 78% of clinicians rating it as useful or very useful. All of the other assessment measures were rated as "useful" or "very useful" by an average of 88% of respondents. In general, the responses to the evaluation questionnaire showed that the clinicians rated the QuickScreen assessment as a valuable and functional addition to their clinical practice and 94% of respondents stated that they would continue to use it in the future.

All of the clinicians stated that they did use the education sheets provided and more than half of the respondents (60%) thought that their patients had complied with the recommendations included in the education sheets, with the remaining people answering that they were unsure of whether their patients had complied or not.

When asked how they would modify the assessment tool for future use, most people did not make any specific suggestions, however one respondent stated that a 1-2 test assessment would be preferable since time is a constraint on use. Another comment was that the touch test was time consuming and that more instructions were needed for this test and one clinician suggested that there should be measures of proprioception, walking aid use and a more specific balance test included in the assessment.

Overall the response from the clinicians was positive and the main reason cited for not using the assessment more often was lack of time, which seems to be a common experience for many health practitioners. The fact that 7 of the original 25 GPs recruited to the feasibility study (28%) dropped out prior to completing the study, however demonstrates that this assessment may be more suited to use by nurses and physiotherapists, who were more compliant in this study. Many GPs have constant demands on their time and may find it hard to provide preventative health advice to their older patients who are often dealing with multiple chronic health complaints as well as acute problems on a regular basis. It is envisaged therefore that in the future the promotion of the QuickScreen assessment as a clinical falls risk tool will focus on allied health professionals rather than medical practitioners.

Risk factors found by clinicians

A total of 258 completed patient assessment forms were returned to the study researcher by the clinicians. Collation of the data showed that only 8% of patients displayed no risk factors and at the other end of the scale, 26% of the patients displayed 5 or more risk factors, placing them at almost nine times the risk of falling as an individual with no risk factors. Overall, more than half of the sample (57%) displayed at least 3 risk factors, placing them at an increased risk of falling. As can be seen in Table 7.2, the most common risk factor identified was multiple medications, found in 61% of patients followed by an inability to complete the near tandem stand task (49%) and the occurrence of previous falls (44%). The least common risk factor was the taking of psychotropic medications (17% of patients). These figures show that fall risk factors are commonly present in community-dwelling people and are comparable to the rates of occurrence of these factors in the validity study sample described in chapter six (page 135).

Table 7.2: Prevalence of risk factors in the patients (n=258) assessed by the clinicians in the feasibility study (number [%])

	Clinicians that identified the risk factors		
Risk factor	**GPs**	**Nurses**	**Physios**
Previous falls	66 (45)	13 (39)	34 (44)
Four or more medications	97 (66)	22 (67)	39 (51)
Psychoactive medications	31 (21)	4 (12)	8 (10)
Visual acuity	46 (31)	14 (42)	34 (44)
Touch sensation	65 (44)	12 (36)	21 (27)
Near tandem stand test	70 (47)	20 (61)	37 (48)
Alternate step test	51 (35)	14 (42)	22 (29)
Sit to stand test	43 (29)	7 (21)	17 (22)

7.5 Other settings where the QuickScreen has been implemented into clinical practice

The Association of Australian Rural Nurses falls risk assessment and prevention project

As mentioned in chapter two (page 48), a project was undertaken by The Association of Australian Rural Nurses (AARN) between the years 2003 and 2005 which had a falls prevention focus. It aimed to develop a resource for rural and remote nurses to improve their knowledge of falls in older people and allow them to undertake clinical and environmental assessments with community-dwelling people in rural and remote locations in Australia. One item which was included in the resource tool was a preliminary version of the QuickScreen clinical falls risk assessment. As part of this project, workshops were conducted around Australia to educate health professionals (mainly nurses) about falls risk assessment and prevention and to train people in the use of the resource tool, including the QuickScreen assessment. The final report which was compiled as a result of the AARN project is included in the Appendix. After the workshops were complete, as part of this thesis, a survey was sent to the 232 workshop participants to gain their feedback about the QuickScreen assessment and its use in their particular clinical environment (see the Appendix). Disappointingly only 60 surveys were returned to the author, representing 26% of those distributed and 12 of these respondents indicated that although they had taken part in the AARN workshop, they were not actually involved in using the QuickScreen assessment as part of their usual work, so they were unable to complete the evaluation survey. Nevertheless, the results of the other 48 responses are summarised here.

The majority of respondents (54%) found that the QuickScreen assessment took approximately 8-10 minutes to complete and the three main settings where the assessments were carried out were in patient's homes, in community centres and in clinics. 60% of the questionnaire respondents said they had not used any falls risk assessment tools previously and the remaining 40% of respondents had used various assessment tools in the past, yet most said that in comparison, the QuickScreen was quicker and easier to use than other assessments. Furthermore, at least 80% of people rated the individual test components of the QuickScreen as useful or very useful, with the alternate step test and near tandem stand test gaining the highest approval ratings. 90% of respondents stated that the QuickScreen assessment assisted with the medical management of their patients and 88% of the respondents stated that they would continue to use the QuickScreen in the future. These positive survey results are similar to the feedback received in the feasibility study outlined above and provide further confirmation that the QuickScreen assessment is an appropriate and useful tool for routine clinical care.

The Royal College of Nursing Australia general practice nurses project

A similar project to the AARN falls prevention project discussed above was the Royal College of Nursing Australia (RCNA) general practice nurses, falls prevention education project. This project is briefly mentioned in chapter two (page 48) and the aim of it was to develop a national falls prevention and assessment education program specifically suited to the needs of general practice nurses. The results of a pre and post-workshop survey carried out by the project will be summarised here and the full report can be found in the Appendix.

There were a total of 87 pre-workshop surveys completed but only 34 post-workshop surveys completed, hence the results are incomplete, but do give some insight into the outcomes of the project. Overall, the workshops appeared to improve the awareness of the nurses regarding the scope of falls as a public health issue for older people and improved their knowledge about risk factors and interventions for falls prevention. The workshops also introduced the nurses to the QuickScreen clinical falls risk assessment and improved their confidence in being able to carry out the assessment as a regular part of screening their older patients. It was encouraging to see in the post workshop survey that all of respondents stated that they believed that general practice nurses can contribute to falls prevention in older people. This result shows that with a small amount of education and with the right tools, general practice nurses can be trained to take on the role of falls prevention with their patients and to feel confident in that role. This may be a good alternative to relying on GPs to assume the role since they may lack the time to do so.

The Stand Up Right- Stay Upright project in Tasmania

Stand Up Right- Stay Upright was a project that was instigated as part of the National Falls Prevention for Older People Initiative [185], that was funded by the Federal Government Department of Health and Ageing and managed by the University Department of Rural Health, at the University of Tasmania. Stage one of the project aimed to increase the level of falls prevention activity in Tasmania by supporting and linking existing services and by the development of two initiatives based in two different clinical settings. The first of these two initiatives was the Department of Emergency Medicine (DEM) initiative at Royal Hobart Hospital, which is not relevant to this thesis and will not be discussed here. The second initiative was the General Practice/ Enhanced Primary Care (GP/EPC) initiative in Northern Tasmania. The GP/EPC initiative involved the implementation of the QuickScreen clinical falls risk assessment into the general practice setting. The QuickScreen assessment was linked with the EPC Health Care Assessments (HCA) which was mentioned in chapter two (page

52). At the conclusion of the project, 111 patients had been assessed with the QuickScreen assessment and the average number of risk factors found was three. The most commonly occurring risk factors in these people were multiple medications, inability to complete the near tandem stand test and impaired low contrast visual acuity, which were similar findings to the feasibility study mentioned earlier in this chapter and the second external validity study described in chapter six. Interestingly, the project found that failing tests in the QuickScreen assessment gave patients more of an incentive to be proactive about trying to reduce their falls risk factors, especially when compared with only receiving general advice about falls risk factors. Overall, the GP/EPC project was deemed to be successful and the specific findings were that:

- There was increased co-operation between practice nurses and GPs.
- The early identification of falls risk factors in elderly people was increased.
- The management of falls risk factors was improved through the structured framework of the project and the subsequent improvement in the motivation of the patients to change their behaviour.
- One barrier to falls prevention interventions highlighted by the project was the lack of referral resources available, particularly in rural areas.

During the Stand Up Right- Stay Upright project, the practice nurses who had trialled the QuickScreen assessment as part of the EPC HCA for people aged 75 years and over, were surveyed after they had been using the assessment tool for several months. They were asked about how the tool fitted in with their work, both in regards to their interaction with the GPs and with the patients and also about how the tool compared to other tools they were using. The overall response was that the QuickScreen assessment fitted easily into the HCA process and was a useful addition to it. The fact that the QuickScreen assessment actually tested the physical capabilities of the patients instead of relying on them to simply answer questions about their capabilities was acknowledged as a more accurate way of measuring risk factors. Following on from this, several respondents to the survey reported that the QuickScreen assessment identified some older people as being at risk who would not otherwise have been considered to be at risk of falling, if clinical judgement alone was used to decide this. This finding is in accordance with previous research that has highlighted the limited accuracy of clinical judgement as a means of determining the presence of chronic health complaints in the general population [138]. Additionally, the use of the QuickScreen assessment prompted the nurses to discuss falls risk factors with clients and other health professionals and improved their confidence in this area.

Stage two of the Stand Up Right- Stay Upright project was aimed specifically at targeted training and education about falls prevention for GPs and practice nurses. An education package was distributed state-wide and seven medical practices in the state's north-west were given the QuickScreen assessment to use. The evaluation report from stage two can be found in the Appendix. One of the main findings of the project was that early identification of falls risk factors in people aged 75 years and over by practice nurses was improved, however this was not the case in the GP group. Most nurses appeared to enthusiastically use the QuickScreen as part of the HCA and reported that it was an important factor in improving their awareness regarding risk of falls. It also enabled them to discuss this topic with their patients and provided evidence to support the implementation of strategies to reduce a patient's specific areas of falls risk. Most nurses said that they would continue to use the tool in the future, with lack of time being the main barrier to future use.

Clinical Overview resource

Following on from the project outlined above, the QuickScreen information has also been included in a Clinical Overview resource [186] which was developed as part of the Stand Up Right- Stay Upright project. The resource was designed to be a "desk top tool" for use by GPs and practice nurses as a quick and accessible source of information about fall risk assessment and prevention and patient referral options. Hopefully it will further encourage the use of the QuickScreen assessment into everyday clinical use, by acting as a reminder and quick reference guide for both clinicians and patients alike.

In summary, the overall outcome of the GP/EPC initiative of the Stand Up Right- Stay Upright project was that the QuickScreen clinical falls risk assessment was considered to be a useful tool for assisting GPs and practice nurses to identify people at risk of falls and to identify which specific factors were placing them at risk. In general, the response of the clinicians in this Tasmanian project to the QuickScreen assessment was very positive, however the uptake of use was greater in the nurse group compared with the GPs.

7.6 Discussion

The feasibility study which was conducted with GPs, physiotherapists and practice nurses was the final phase in the development of the QuickScreen clinical falls risk assessment. The feasibility study was needed because no matter how rigorously tested and evidence based an assessment of falls risk factors is, there is little point in promoting it as a tool for use in a clinical setting if it has not gained acceptance in the “real world” settings for which it is designed. This study aimed to assess how acceptable the QuickScreen assessment was to the clinicians that it was designed for, in light of the usual time constraints and work pressures that clinicians are faced with on a daily basis.

The results of the study show that the QuickScreen assessment is an appropriate and acceptable tool for determining a patient’s risk of falling and for instigating strategies to reduce those risks. The positive response to the assessment by the clinicians is evidence of the quick, simple yet informative nature of the assessment. On average the users reported that the QuickScreen assessment could usually be completed in ten minutes and its components were found to be useful and relevant. The education sheets distinguish this assessment from others previously developed because not only can the clinicians determine who is at risk of falling and which factors contribute to that risk, they can also implement strategies immediately to try to reduce these risks. A wide range of clinicians trialled the QuickScreen assessment in a variety of settings and overall it was found to be a valuable addition to their clinical practice. This demonstrates the versatility of the QuickScreen as an assessment tool for many applications.

Despite these positive results, it is acknowledged that there was a relatively high drop-out rate from the feasibility study amongst the general practitioners. 25% of those GPs originally recruited to the study dropped out prior to completion, which, while not unusual for this type of evaluation survey, may have lead to a certain degree of response bias, where the most motivated and enthusiastic participants were the final respondents to the survey. Therefore, the results of the survey are encouraging, since a significant percentage of respondents found the QuickScreen to useful and beneficial to their clinical practice, yet the findings cannot be generalised to all occupational groups.

The AARN project provided the opportunity for further evaluation of the appropriateness of the QuickScreen assessment in an additional setting; rural and remote areas in Australia. The results of the project have shown that the assessment, in conjunction with the background information on falls prevention and additional information about risk factors not assessed by the QuickScreen, was very beneficial in creating awareness about the scope of the problem of falls in older people and about the role that nurses can play in preventing falls in this setting. The project participants came away from the experience with an increased knowledge of fall risk assessment and prevention and an increased level of confidence regarding their role as providers of solutions to this serious public health issue.

As was the case with the AARN project, the feedback from the RCNA project and the Stand Up Right- Stay Upright project further reinforced the acceptance of the QuickScreen assessment by clinicians and highlighted the gap in clinical practice that the QuickScreen is able to fill. Again as a result of their participation, many of the clinicians in these projects cited an increased sense of ownership over the role of educator and provider of falls prevention advice and strategies for older people. The QuickScreen assessment compared well to other falls risk assessments that the clinicians had used and blended in well with services and protocols that already existed in some areas. The fact that the QuickScreen assessment is able to complement and strengthen existing work practices is important for maximising clinical acceptability and will hopefully lead to continued use in the future.

The QuickScreen assessment was originally devised as a tool for general practitioners to use. This feasibility study has shown, however that GPs have many competing demands and time constraints, which make it difficult for them to fit the assessment into their existing work practice. For this reason and because of the positive response to the QuickScreen from the other health professionals, both in the feasibility study outlined in this chapter and in the other projects conducted by external agencies, it may be more feasible for these other health professionals to undertake as part of their routine care of the older patient; for example as part of the enhanced primary care yearly health assessments which are carried out by practice nurses.

Chapter Eight

Discussion and conclusion

8.0 Overview of main study findings

The aim of this thesis was to develop a falls risk screening assessment that had proven validity for the prediction of falls in older people and was multifactorial, included measures that were reliable over time and suitable for use in clinical settings with a variety of clinicians. As is outlined in the previous chapters, these aims have been met and the result is the QuickScreen clinical falls risk assessment. This assessment is a rigorously tested multifactorial falls risk assessment which is suitable for the confines of busy clinical settings to assess older community-dwelling people. It has proven to be practical for this setting and has been welcomed by the clinicians who were included in the formal trial carried out as part of this thesis, as well as by other health practitioners who have used the assessment during the course of other projects run by external organisations. In all, approximately 340 clinicians have used the QuickScreen assessment from a variety of professional backgrounds as part of formal projects. In addition to these people, the assessment has also been obtained and used by people working in private organisations around Australia which total approximately 40. There has also been an expression of interest in the QuickScreen assessment from researchers working at the British Columbia Injury Research and Prevention Unit in Victoria, British Columbia, Canada who are developing a falls prevention curriculum for health professionals. Overall, the demand for the QuickScreen assessment since the commencement of this project has highlighted the need for a validated clinical falls risk assessment that existed before its conception.

One phase in the development of the QuickScreen assessment was to determine the test-retest reliability of the test performance measures. This is an important aspect of any measure of function since a reliable measure can give an accurate picture of how a person's performance changes over time, which may occur as a result of an intervention (where performance would improve) or as a result of a decline in health or disability (where performance would be expected to worsen). In this study, the assessment measures included in the final QuickScreen falls risk assessment displayed reliability coefficients that ranged from good to excellent.

The construct validity study showed that the QuickScreen assessment measures were related to the validated sensorimotor falls risk measures that comprise the Physiological Profile Assessment (PPA) [117]. The PPA is a comprehensive falls risk assessment which is able to predict future fall status with an accuracy of 75%, but which is not suitable for many clinical settings where time and cost are constraints on its use, which prompted the development of the QuickScreen clinical falls risk assessment. The subsequent external validity studies showed that the individual measures included in the QuickScreen assessment displayed a good ability to distinguish between multiple fallers and non-multiple fallers when tested with two large samples of community-dwelling older people. Additionally, when the critical level of 4 or more risk factors found by the QuickScreen assessment was used to define high falls risk, the sensitivity and specificity of the assessment for predicting multiple fallers were 76% and 60% respectively. This good but not excellent result shows that the necessity of simplifying the tests and using cut points instead of continuous scores led to a reduced (but anticipated) loss of predictive accuracy, when compared to the PPA.

The final stage in the development of the QuickScreen clinical falls risk assessment was a feasibility study, the results of which revealed an acceptance of the assessment by a variety of health practitioners and by their elderly patients. The clinicians found the assessment quick and easy to administer and the majority of them stated that they would continue to use it in the future to aid in the management of their elderly patients. The feedback from the practice nurses that were involved in the Stand Up Right- Stay Upright project was particularly valuable in reinforcing the usefulness of the QuickScreen assessment for the clinical setting. The nurses found the tool to be very informative and they found that it challenged their clinical judgements of patients that may not always be correct. This was both in relation to people who they perceived to be at a low risk of falling, who were actually found to have several measurable risk factors and vice versa. Many people also commented that the QuickScreen acted as a starting point to look at a range of additional factors that may pose a risk for falls such as environmental hazards.

8.1 Limitations of the study design

Despite the positive results of this study as a whole, there are some limitations to the study design which need to be included here. Firstly, in the initial validity study, which aimed to determine the underlying sensorimotor factors which were associated with performance in the functional balance and mobility tests, the comparison variables included were only those that comprise the PPA. This limited the amount of information that could be gained about the functional tests and meant that other physiological factors that may have been related to performance in the tests, for example hip extension and flexion strength, and ankle flexibility were not included in this analysis.

This thesis has outlined the development of the QuickScreen clinical falls risk assessment which is able to identify which community-dwelling older people are likely to fall in the future and to also identify modifiable risk factors within the individual in order for appropriate intervention strategies to be implemented. This thesis however, has not assessed whether modification of the risk factors identified by the QuickScreen assessment is actually effective in reducing fall rates in a randomised controlled trial format. This would be the most accurate measure of the effectiveness and utility of the QuickScreen assessment, but was beyond the scope of this thesis.

The QuickScreen assessment is designed for community-dwelling people without cognitive impairment, which is a validated risk factor for falls [5, 48]. As such, the assessment does not include a measure of cognitive impairment. The reason for this is that it is assumed that most health professionals would already be including a measure of cognition as a part of their usual patient care and so it would be a replication of clinical practice. However, fall rates are very high in older people with this condition. For example, Tinetti et al. reported a 12-month fall incidence rate of 67% in 24 community-dwellers with cognitive impairment as part of a larger trial [5] and Shaw et al found that 80% of the 114 subjects presenting to an accident and emergency department fell within a prospective period of one year [187]. These high incidence rates indicate that cognitive impairment is a strong risk factor for falls and requires a specific assessment. For future use, clinicians who are using the QuickScreen assessment will be advised to include an additional measure of cognition such as the Short Portable Mental Status Questionnaire (SPMSQ) if this is not a part of their usual patient care.

A further weakness in the design of the validity studies is that people were excluded from participation in these studies if they were cognitively impaired or if they had poor English language skills. These exclusions mean that the results found here cannot be translated to these specific groups of people and therefore the ability of the QuickScreen assessment to predict falls in these populations is not known.

Lastly, another limitation in the design of this project is that the clinicians in the feasibility study were not randomly selected. Rather, they were people who were already interested in falls prevention or had some previous clinical experience with it. Furthermore, there was a 25% drop-out rate amongst the GPs in the feasibility study, which may have led to response bias in the evaluation questionnaire, since it is likely that the GPs who were motivated and enthusiastic were the people who remained compliant in the study. Therefore, a more randomly selected group of clinicians may have given a more unbiased view of the usefulness of the QuickScreen assessment as part of an existing clinical framework. This design weakness is however offset by the results of the external projects, which were reported in chapter seven, which have trialled the QuickScreen assessment with a general practitioners and nurses in a variety of locations and which have also reported a very positive acceptance of the QuickScreen by these health professionals.

8.2 Strengths of the study design

In addition to the demonstrated reliability and validity of the QuickScreen assessment measures which has been outlined in this thesis, one of the main advantages of this tool compared with other falls risk assessments is that its scope is multifactorial and therefore it is more likely to identify people who are at risk of falling due to a number of causes. This is particularly important since it is widely accepted that falls occur due to many different factors, which vary from person to person. Hence, a risk assessment which focuses only on strength and/or balance risk factors, which is often the type used in current clinical practice, may be likely to misclassify people who are at risk of falls due deficits in other physiological systems such as vision, peripheral sensation or medication usage. Additionally, the measurement of several modifiable risk factors within one assessment allows the clinician to instigate multiple strategies for risk reduction which are tailored to the needs of the patient. This is important since the aim of a clinical risk assessment should not only be to identify who is at risk of falls, but to also initiate intervention strategies for the reduction of risk in the future. For example, there is abundant evidence showing that previous falls place a person at an increased risk of falls in the future [4, 50]. So, it might be thought that all a clinician needs to do is to ask the patient whether they have had any falls in the previous 12 months, to determine if they are at risk of falling in the future. This approach however, while identifying potential fallers, does not provide the clinician with any useful information about which particular factors are likely to be contributing to the individual's risk of falling and hence what interventions are necessary to reduce that risk. In other words, an assessment of falls risk is only useful if it is followed up with an appropriate intervention plan aimed at reducing specific risk factors, which is what the QuickScreen assessment can provide.

For the external validation of the entire group of QuickScreen measures, the data from four separate study cohorts, totalling over 1100 subjects, was pooled in order to maximise the subject numbers and to obtain a more representative sample of people with a wide range of ages and physical abilities than would have been obtained from studying a smaller cohort in isolation. The advantage of this is that it makes the results of the study applicable to the general population of community-dwelling older people and means that clinicians should be able to use the QuickScreen assessment with a wide variety of their patients and have confidence in the results. Furthermore, in the validity studies, falls were measured prospectively which is known to be more accurate than relying on the recall of previous falls in a retrospective design [100].

One of the advantages of the current study is that not only has it assessed the validity and reliability of the QuickScreen assessment but it has also determined if the assessment is feasible for use in several “real world” clinical settings. This is a definite advantage of the QuickScreen compared with other existing assessments, because if there is poor acceptance of an assessment by the clinicians that it is designed for, then the scientific evidence regarding its reliability and validity is irrelevant since the tool is less likely to be utilised for the assessment and prevention of falls in older people.

8.3 Implications for clinical practice and public health policy

The QuickScreen clinical falls risk assessment is currently being used by several hundred clinicians in various locations around Australia, which is encouraging (or perhaps frightening) in light of the fact that the research outlining its content and scientific validation is yet to be published. My immediate goal is to submit these findings for publication in a peer reviewed journal. Following on from this my goal is to have the QuickScreen clinical falls risk assessment included in the guidelines for the standard assessment which makes up the Enhanced Primary Care Health Care Assessments (EPCHCA), which are available to people aged 75 years and over (55 years and over for aboriginal and Torres Strait Islander populations). This would mean that when GPs and practice nurses carry out one of these assessments, they would include the QuickScreen assessment as a standard procedure to determine the level of risk that a person has for future falls. The first step in making this happen would be to lobby policy makers in the Department of Health to recognise the need for a more comprehensive falls risk assessment as part of this annual screening assessment and to demonstrate how the QuickScreen fits this need.

Additionally, since the EPCHCA are only relevant to people who are aged 75 years and over, there is a need for people who are younger than this to also be screened to determine their risk of falling so that early intervention can be instigated as a means for preventing falls. This makes sense from a public health perspective and may be a more cost-effective approach to the problem of falls in older people than just treating people after a fall occurs. To further increase the awareness of the need for falls risk assessment and prevention by health practitioners, the results of this study will be presented at scientific conferences and to community and health professional groups during the next year. This will hopefully encourage a greater understanding amongst clinicians of the need to include falls risk assessment as part of their usual patient care.

The QuickScreen assessment would also be a valuable addition to settings where exercise programs are being run for older people, both with a focus on falls prevention but also more general programs designed to improve the general health and well-being of older adults. By conducting the QuickScreen assessment on all exercise group participants at the time of their enrolment, exercise leaders could gain a greater understanding of the physical capabilities and deficits of their clients and could use this information to direct specific aspects of their exercise programs, with more positive outcomes as a result.

8.4 Conclusion

As has been outlined in this thesis, there are numerous assessment scales which have been developed over the past twenty years for the purpose of identifying falls risk factors in older community-dwelling people. Many of these assessments, however, are one dimensional; often only assessing balance or leg strength alone and therefore would be unlikely to identify potential fallers who have deficits in other important areas of risk. Furthermore, in many cases the precision of these assessments for the prediction of risk has relied on the categorisation of people as fallers and non-fallers on the basis of retrospective falls data, which is known to be of limited accuracy. This leaves the ability of these measures to predict future falls somewhat unknown. Another downfall of many existing falls risk assessments is that they are not suitable for use in busy clinical settings, where the administration time, need for specialised equipment and/ or complicated test protocols make them impractical for clinicians to use. Additionally, even when the outcome of an assessment does predict risk of falling, existing falls risk assessments usually do not provide guidance regarding effective intervention strategies which may reduce falls in the future.

The aim of this thesis was to address these issues and to develop a falls risk assessment which is suitable for use in a variety of clinical settings. The QuickScreen assessment is the outcome of this research and the results outlined here show evidence of its validity, reliability and feasibility for use in several different settings. It is hoped that the QuickScreen will continue to be used in the future to aid in the early detection of those individuals who are at risk of falling, so that preventative measures can be implemented and the burden of falls to the community can be reduced.

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Appendix

FALLS AND MEDICAL CARE CALENDAR

Falls in the month of July 2001
place a tick on the date of any falls

SUN	MON	TUES	WED	THURS	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

[ ] I had **NO** falls this month

Please phone when you have a fall even if it was a minor fall. Phone number **9926 8160**

Medical Care in the month of July 2001
Have you used any of the following medical services this month?Y/N
Please indicate the number of times you have used each service in the past month
EVEN IF IT WAS NOT RELATED TO A FALL

Medical Service	**Number of times used**	**Was the use initiated because of a fall?**
General practitioner visit		
Specialist doctor visit – please specify:		
Other practitioner such as physiotherapist, home nurse – please specify:		
Diagnostic test such as blood test / X-ray – please specify:		
Hospital care – please specify:		
Hostel / Nursing home care		

QuickScreen© Clinical Falls Risk Assessment

Testing Instructions

<u>How to use the assessment form</u>

<u>Step 1</u>: Carry out the test/assess whether the risk factor is present or not.

<u>Step 2</u>: Circle Yes or No in column 2.

<u>Step 3</u>: If you circled Yes, refer to the intervention recommendation for that factor.

<u>Step 4</u>: In column 3 write down what action needs to be taken to reduce/remove the risk factor.

<u>Step 5</u>: Add up the number of risk factors present and refer to the table at the bottom of the page to calculate the total risk increase.

<u>Step 6</u>: Give the patient feedback about their risk of falling and which interventions are appropriate to reduce that risk.

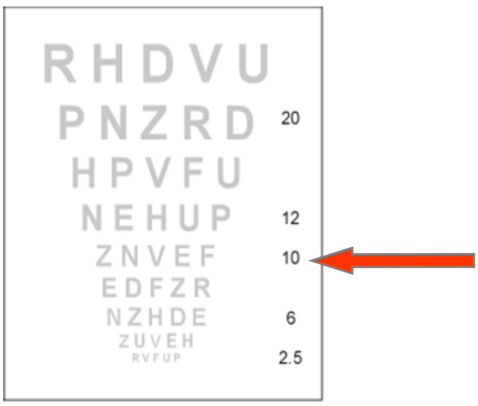
NB: The section on previous falls contains no recommendation, however if this is the only risk factor that a patient displays, you should consider investigating other factors not covered by this assessment, such as lower limb arthritis, postural hypotension and the need for home modifications.

<u>How to carry out the assessment</u>

Low contrast visual acuity test

Visual acuity is measured using a chart with low-contrast (10%) letters (similar to a Snellen scale).

<u>Procedure</u>



The patient is seated at a distance of three metres from the visual acuity chart which is mounted on the wall at eye height, under a good source of light. They wear the glasses they would normally wear for distance vision. Ask them to read out the lowest line of letters they can read easily on the chart. Point to the next line down and ask them to read out the letters. Continue to move down the chart until they cannot see the next line or until they score all errors. The lowest line read and the number of letters correct is recorded.

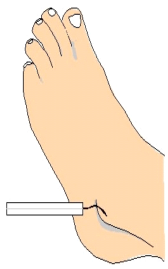
<u>Score</u>
The patient must be able to correctly identify all of the letters on line 10 (fifth line down) to pass the test.

For the remaining tests, the patient needs to remove their shoes and socks

Tactile sensitivity test

This test involves the use of a pressure aesthesiometer placed on the lateral malleolus of the ankle of the dominant side. The patient is seated.

<u>Procedure</u>



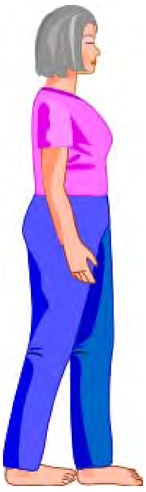
The patient is asked to keep their eyes closed throughout the test and indicate to the tester (by saying "yes") if they can feel the monofilament being placed on the lateral malleolus of the ankle. The filament is applied for 1 second and pressure applied until it bends. If the filament "flicks off" the trial should be repeated. One practice trial and three test trials are given.

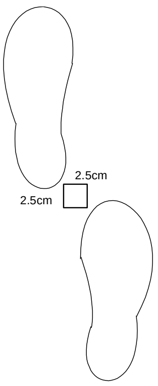
<u>Score</u>
The patient must be able to feel at least two of the three test trials to pass the test.

Near tandem stand test

This is a measure of balance and ankle strength and involves testing whether the patient can stand with feet in a near tandem position for a period of 10 seconds with their eyes closed. Equipment required is a stopwatch and 2.5cm square cardboard template for foot positioning.

<u>Procedure</u>





Demonstrate the position of the feet first and explain that the test involves standing in this position for 10 seconds with eyes closed. Allow the patient to choose which foot they place in the forward position for the test. Use the square template to separate the feet laterally by 2.5cm and the heel of the front foot 2.5cm anterior to the great toe of the back foot (see diagram at left). If the patient is unsteady, support them as they assume the test position. When they are in position and steady, remove your support and ask them to close their eyes and balance in that position without moving their feet, until you say "stop". Start timing from when they close their eyes. If a time of 5 seconds or less is obtained, a second trial is allowed and the better result is used as the final score.

<u>Score</u>
The patient must be able to balance in this position for at least 10 seconds to pass the test.

Alternate step test

This is a measure of strength, balance and co-ordination. Equipment required includes a stopwatch and 18cm high step.

Procedure

Demonstrate the task first: place the right foot onto the step, supporting the body weight with the left, then place the right foot back on the ground and place the left foot onto the step. Emphasise that the whole foot should be placed onto the step, but the body weight remains supported by the grounded leg (i.e. the patient is not required to actually step onto the step). The task is to be completed as quickly as possible, 4 repetitions per foot, alternating right and left. Start timing from when the first foot is lifted off the ground and count aloud each of the 8 foot taps.

Score
The patient must complete the task in less than 10 seconds to pass the test.

Sit to stand test

This test involves timing how long it takes the patient to stand up and sit down five times from a seated position. Equipment required includes a 45cm high, straight-backed chair and a stopwatch.

Procedure

The patient is asked to perform the movements as quickly as possible with both arms folded in front. Demonstrate the test procedure first, emphasising the need to stand all of the way up until both knees and hips are fully extended and to sit all of the way down for each repetition. Ask the patient to place their feet directly below their knees at the start of the test and keep their arms folded across their chest for the duration of the test. Ask if they are ready and signal the start of the test by saying, “Go”. Start timing from when the shoulders first move forwards and count aloud each repetition. Stop timing when they have completed five repetitions and are seated.
Safety: Make sure the chair doesn’t move back when the patient sits down by steadying it against a wall or with your hand.

Score
The patient must complete the task in less than 12 seconds to pass the test.

Patient education sheets included in the QuickScreen assessment kit

Information on how to improve strength, coordination and balance

How can these factors lead to falls?

Adequate strength is required to support the body weight as we stand and walk. A weakness in one leg can result in a fall when all of the body weight is placed on it. Strength is also important for undertaking every day activities such as getting out of bed, rising from a chair and walking up and down steps.

Good static and dynamic balance are required so we keep control of our upright bodies and quick reaction time and good coordination allow us to recover in time if we trip, stumble or lose balance.

What you can do

The best treatment for any reduced functioning in the above factors is exercise.

- Exercise classes are particularly beneficial, as any specific balance, strength or coordination problem can be targeted. Exercising in a group also provides a structure and social support.

- Specific home exercises and increased general exercise such as walking, gardening etc. provide important additional benefits.

Tips for starting and maintaining an exercise program

- Begin slowly and gradually build up the amount of exercise you do.
- You don't have to do all of the exercises at once. Spread them out and do some in the morning and some in the evening if you like.
- Choose an activity that you enjoy and that you feel comfortable doing.
- Exercise with a friend or in a group- it is more enjoyable if you have someone to talk to.
- Vary your walk route and choose interesting places to visit, such as a park or beach.
- Don't exercise during the hottest part of the day.
- Set weekly goals that are achievable.

Information about how to compensate for Sensation Loss

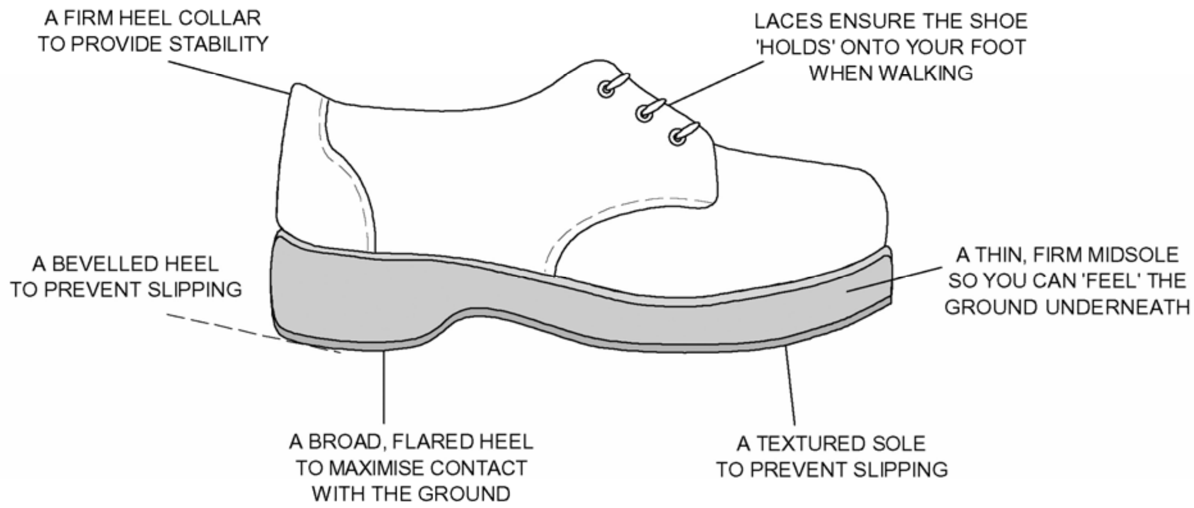
How can sensation loss lead to falls?

Leg sensation provides information to the brain about your standing position and your leg movements as you undertake activities like walking and getting in and out of a chair. Imagine if your legs were totally numb – they would provide no information to the brain at all.

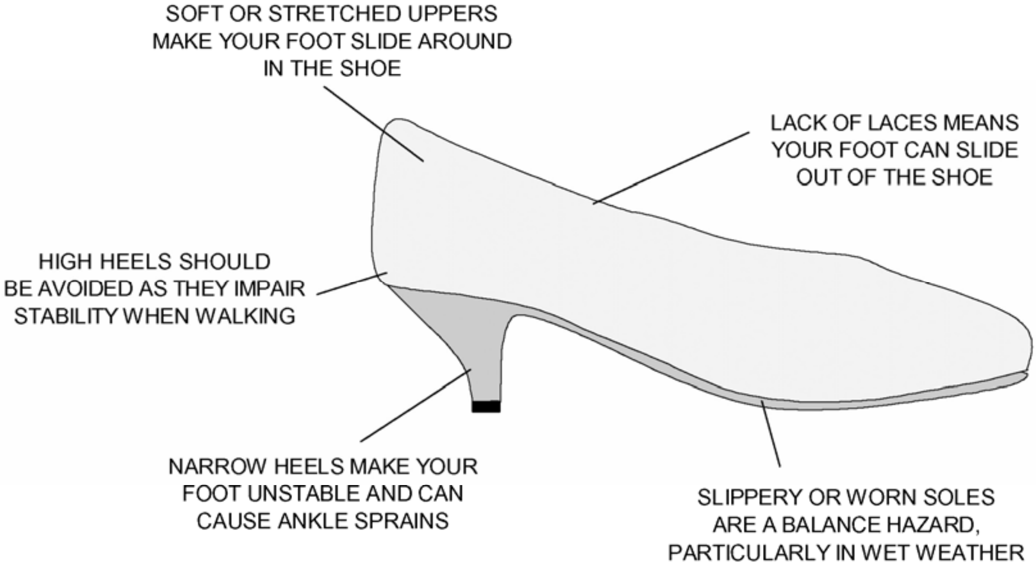
What you can do

- Take particular care when walking on surfaces that are uneven or soft, i.e. footpaths, uneven or rough ground and thick carpets and rugs.
- Avoid walking in dim or unlit areas if possible and make sure you turn the light on before walking in the house at night.
- Wear shoes with low heels and firm rubber soles to maximise leg sensation and balance.
- Visit your doctor to assess whether any medical condition could be leading to your sensation loss.
- Consider using a walking stick or a sturdy umbrella as a sensor (rather than/or in addition to a support) to help you compensate for sensation loss. For example a stick gives extra information about footpath and road cracks and irregularities.

What makes a shoe safe ?



What makes a shoe unsafe ?



Information about how to maximise your vision

How can reduced vision lead to falls?

People with reduced vision have an increased risk of tripping over objects within the home and especially when outside in unfamiliar surroundings. This is particularly the case in circumstances that are sub-optimal, e.g. in poor lighting conditions, at dusk, in high glare situations and when the light intensity changes – i.e. going from bright light into the dark and vice versa.

The ability to see edges in the environment and judge distances are the most important visual functions for safe mobility and avoiding falls. Good vision in both eyes is important for judging distances and depth, so it is important to maximise vision in both eyes.

Bifocals, trifocals and multifocals make things worse - even in those who have been wearing them for years. The problem with these glasses is that their lower sections blur obstacles on the ground we need to see to avoid tripping.

What you can do

- Have your eyes assessed every year by an eye doctor.
- Wear only a single-lens pair of glasses (i.e. no bifocals, trifocals or multifocals) when walking, especially when outside the home.
- Wear your glasses; don't keep them in a drawer or in your pocket.
- Wear a hat and/or sunglasses when outside, especially in bright and high glare situations.
- Avoid dimly lit areas if possible and turn the light on before walking in the house at night.
- Put on your glasses if you get up in the night to go to the toilet.

Home exercise booklet included in the QuickScreen assessment kit

EXERCISES FOR PREVENTION OF FALLS

When you begin an exercise program, you need to remember that bodies that have not been exercised for some time need to be treated gently while they adjust to the new routine. Begin your exercise program by working slowly and safely. It is best to do small amounts often rather than a lot of exercises at once.

These exercises are designed to maintain and improve muscle strength and balance as well as joint mobility and flexibility. Improving your strength and mobility can increase your ability to regain your balance and prevent potential falls from becoming actual falls.

It is normal to feel some slight initial discomfort, especially muscle soreness – this should subside as your body adjusts to the new routine. If you experience pain, dizziness, light-headedness or palpitations stop exercising and talk to your doctor.

If you haven't exercised for some time, it is very important that you use a support. Choose a sturdy chair, table or kitchen bench where your hands can rest at waist height. Try to gradually decrease the amount of support from your hands but keep safe while doing so.

Try to make a habit of exercising. If you do these exercises 2 or 3 times a week, you should notice a difference after 6-8 weeks.

Exercise Program

Each exercise session must have 3 parts – you need to start with a warm-up, then do the main exercises and finish with a cool-down. If you are overweight, spend more time on both the warm-up and cool-down.

1. Warming-Up

This prepares your body for the exercise part of the session by gradually increasing your blood circulation and breathing rate. This part of your program should take about 5-10 minutes. Start with breathing and gentle movements -breathe in as you lift your arms to a comfortable height and breathe out as your lower them again. Do this 3 or 4 times.

March on the spot (remember, you can hold onto a chair or table for support if you need to) or walk around for 5-10 minutes. This will make your blood circulate a little faster and result in your muscles and joints being warmer and ready for exercise.

Walking

Walking is an important part of an exercise program as it improves your heart and lung fitness as well as leg strength and mobility. Try to include 3 walks per week of about 10-30 minutes each, into your weekly routine.

2. Exercise stage

This part will initially take about 10 minutes- gradually you can aim to increase this stage to about 15-20 minutes. Increase the amount of time week by week- gradually work up from 8-12 repeats of an exercise to 3 sets of 8-12, as you feel able to. Rest for 1-2 minutes between each set of 8-12 repetitions. Make sure the exercises are hard enough so that by completion your muscles feel a bit tired. No improvement will occur if the exercises are too easy.

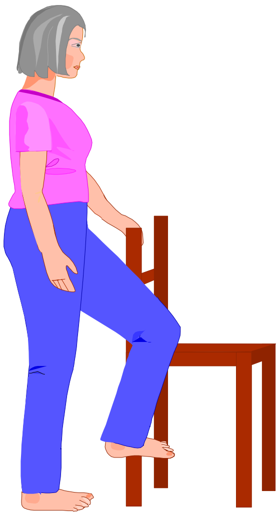
Add a weight to the exercise once you can perform 2 sets of 8 repetitions of the exercise without feeling tired. The exercise should feel “hard” but you should be able to perform 8 repetitions before you need a rest. Increase the weight by 1-2 lbs (1/2 to 1 kg) when the exercise no longer feels "hard". Do not increase the weight if you have pain or discomfort.

For the following exercises, stand next to a chair or table and hold on for support if needed.

Side lift (strength)

Standing sideways to your support, take your outer leg to the side, as far as you can comfortably, keeping the knee straight and the foot facing straight ahead. Hold for 3 seconds and lower. Repeat 8-12 times. Turn and repeat with the other leg. Build up to 3 sets.

Progression: Tie a weight around the ankle (e.g. a 1kg bag of rice) to make the exercise harder.



Knee Raises (balance and strength)

Holding the support with one hand,

raise your right knee up towards yourchest,

hold for 10 seconds then lower. Do this 8-12

times. Repeat with the left leg.

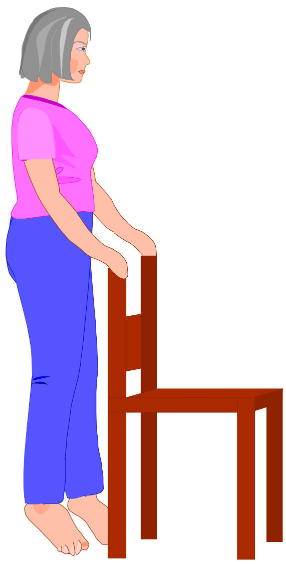
Progression: Tie a weight around the ankle (e.g. a 1kg bag of rice or sand) to make the exercise harder.

Toe and heel raises (strength and balance)

Using both feet, rise up on your toes, hold for 5 secs then lower. Then, keeping heels on the floor, lift your toes, hold for 5 secs, then lower. Repeat both movements 8-12 times. Build to 3 sets.

Progression: As your balance improves, try not to hold on to the support as much.

To progress further, try walking on your toes, then heels.



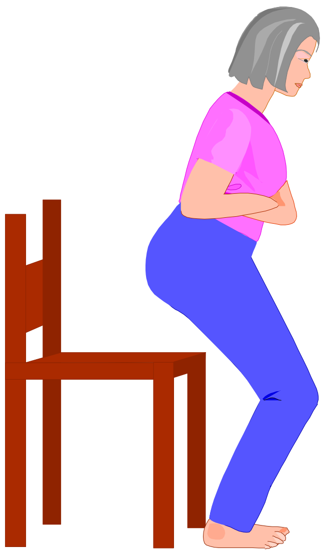
Step ups (strength and balance)

Find a step which has a support nearby, such as a wall or railing. Step up one step, right foot first, then left. Step down leading with the right foot again. Repeat the exercise 8-12 times then change the lead foot and repeat another 8-12 times. Build to 3 sets. Then repeat the exercise by stepping up sideways onto the step.

Leg extension (strength)

Sit with both feet flat on the floor. Gently raise the right leg, straighten the knee as far as you can with comfort and hold for 3 seconds, then lower. Repeat with the left leg. Do the whole exercise 8-12 times with each leg. Build to 3 sets. Don't strain to lift your leg to the horizontal position, gentle practice means it will become easier in time.

Progression: Tie a weight around the ankle (e.g. a 1kg bag of rice or sand) to make the exercise harder.



Sit to stand (strength)

Sit in a straight-backed chair, with feet shoulder width apart. Stand up out of the chair, trying not to use the arm rests for support. Move in a slow and controlled manner. Repeat 8-12 times, build to 3 sets.

Progression: Sit in a lower chair and perform the exercise slower.

3. Cool Down

This stage helps your body return to its normal state by slowing the heart rate and breathing rate. Use gentle movements like marching on the spot and side stepping.

The cool-down is also a good opportunity to do some stretching as your muscles are warm from the exercise and will stretch more easily. Here are some stretches to try, which may help to reduce any muscle soreness:

- With your feet apart, raise one arm above your head or as far as you comfortably can, and "reach for the sky". You should feel some stretch in your torso as well as your arm. Repeat with your other arm. Then raise both arms and stretch upwards, making yourself as tall as possible.
- Stand near a wall, facing the wall, place hands on the wall at shoulder height and shoulder width apart. Take right foot back about 1 metre from the wall keeping the knee straight. Bend the left knee and lean your body forward slightly, keeping back straight until you feel a stretch in your right calf muscle. Hold for 10 seconds then repeat with the left leg at the back and the right knee bent. Repeat 3 times for each leg.

Association for Australian Rural Nurses

Falls Risk Assessment and Prevention Project

Evaluation Report

INTRODUCTION

Stage Two of the Falls Assessment and Prevention Project resulted in the development of the workshop training program and its implementation through ten workshops. This report documents the evaluation of the ten workshops which were facilitated by an AARN Project Officer together with a representative from the local health service where the workshop was conducted.

The workshops were conducted in five states between November 2004 and May 2005. The workshops were held in Toowoomba (2), Warrnambool (1), Dandenong (1), Devonport (1), Campbell Town (1), Loxton (2), Bateman's Bay (1) and Wagga Wagga (1).

Each workshop was evaluated separately, with participant feedback informing appropriate adjustments to future workshops. Pre and post workshop questionnaires were not coded which resulted in an inability to correlate the individual participant changes and information provided before and after the workshops. For simplicity, the information gleaned from the individual workshop evaluations has been collated and then analysed as one body of information.

A pre-workshop questionnaire was completed by participants to establish demographics, and a baseline of current practice and self reported levels of skills, knowledge and confidence in relation to falls assessment and prevention (Appendix A).

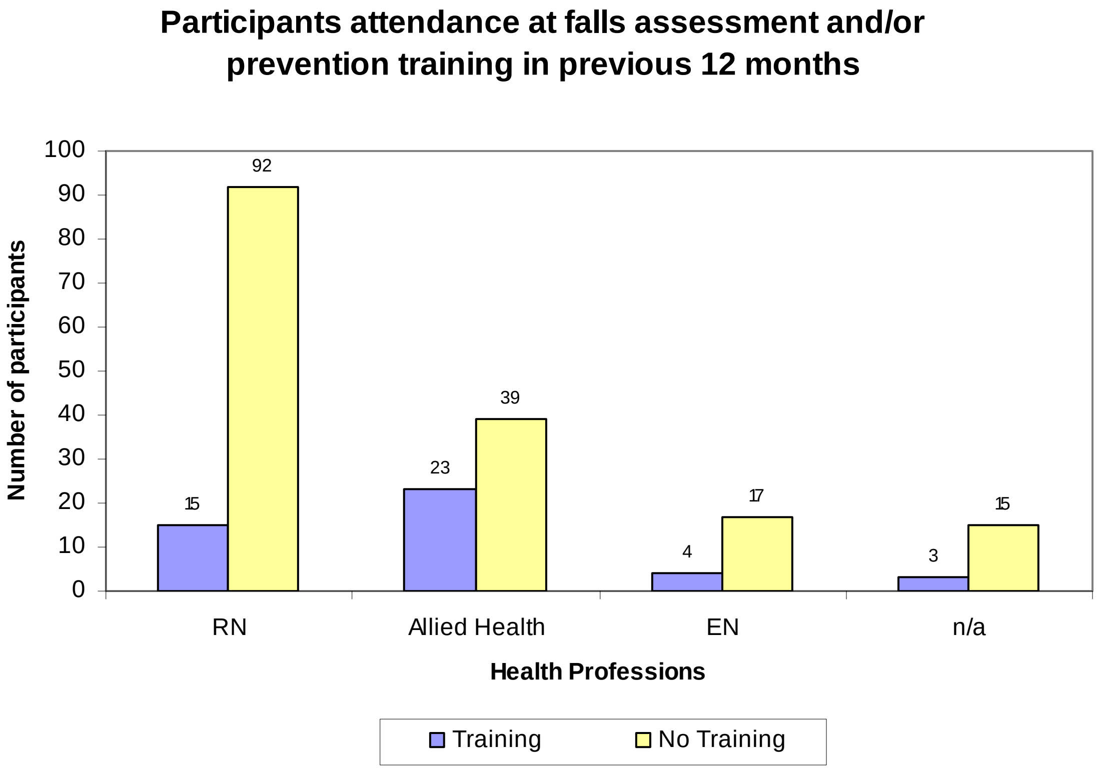
The workshop evaluation was conducted in two parts. Part one was a process evaluation of the workshop, assessing participant satisfaction with the workshop content and design and documentation of new skills learned (Appendix B).

Part two consisted of a further two questionnaires, completed at six weeks and then twelve weeks following the workshop (Appendix C). These were mailed out to participants at 6 and 12 weeks following the workshops with reply paid envelopes for their return. The questionnaires determined access to the Resource Kits, its use and changes to the participant's clinical practice.

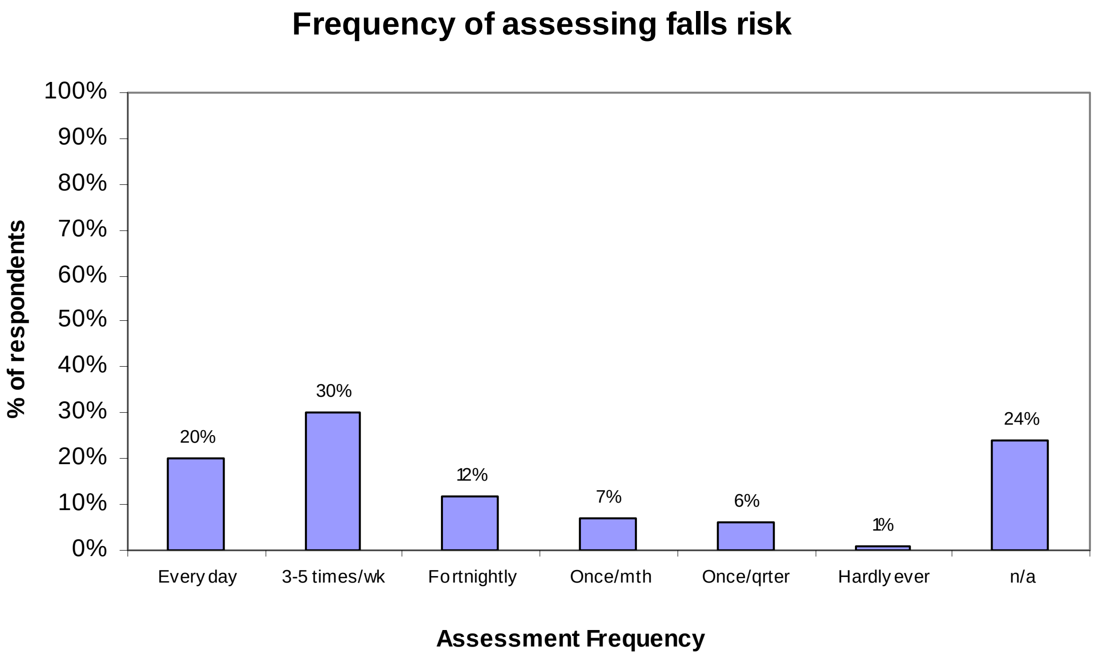
PRE-WORKSHOP QUESTIONNAIRE

Previous Training in Falls Risk Assessment and Prevention, Frequency of Assessing Falls Risk and Currently used Assessment Tools.

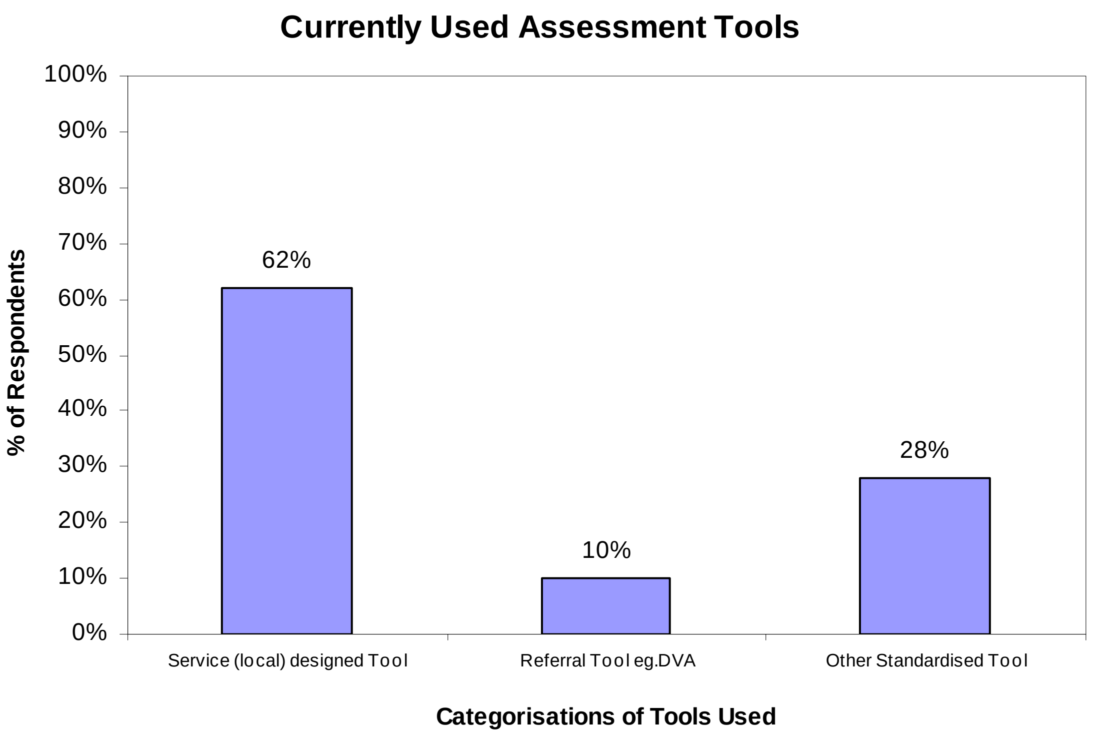
A pre-requisite for participation in the Falls Project was for the health professional to be required to conduct falls assessment as part of their duties. Of the 208 pre-workshop questionnaires returned, the majority of participants had not received training in falls risk prevention and assessment in the previous 12 months despite having to do this as part of their role.



Registered Nurses were the most under trained of the rural health professionals (eg: Physiotherapists) required to undertake falls risk assessment and prevention as part of their duties. Unfortunately the questionnaire did not ask whether any respondents had completed training previous to the last 12 months. This information would have provided greater insight into the skills and ability of rural health workers in relation to falls assessment and prevention.



As the first graph indicates, 78% of respondents had no previous training, although they were expected to be able to conduct falls risk assessment and implement prevention strategies in their communities. In addition to this, 62% of respondents stated that they conducted falls risk assessments at least fortnightly, with 50% of respondents performing assessments 3 – 5 times each week.



The majority of respondents (62%) used locally designed or service-based tools. There is no description of the any other standardised tools (as asked in the questionnaire) used by 28% of respondents.

Knowledge, Skills and Confidence

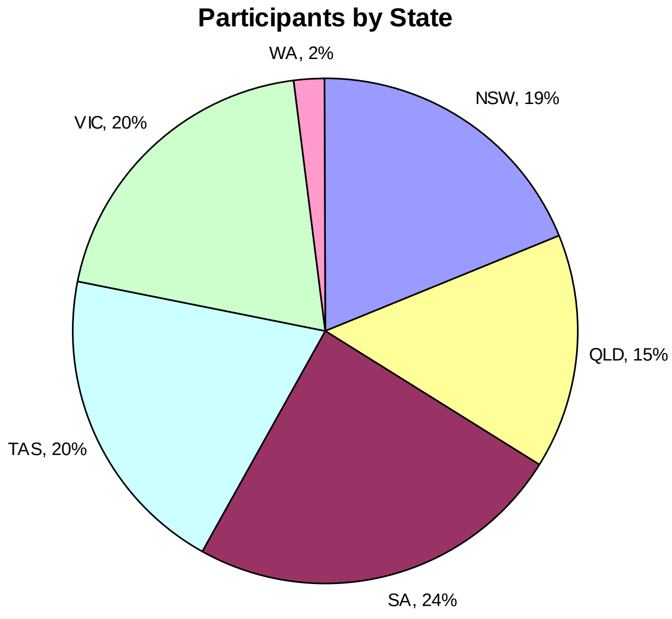
Knowledge, skills and confidence in falls risk assessment and prevention were ranked from 1 to 4 with 1 being the lowest ranking and 4 the highest.
Between 50% and 60% of respondents indicated that they were knowledgeable, skilful and confident in falls risk assessment; in the implementation of prevention strategies and interventions and in liaison with local community resources.

END OF WORKSHOP EVALUATION

The end of workshop evaluation provided immediate feedback on the first impressions of the workshops to the facilitators. This information enabled the facilitators to make appropriate adjustments in the roll out of the remaining workshops. For example, when a significant number of respondents indicated that they were uncomfortable with the role plays and felt that they were not beneficial, the role plays were changed to group discussions for the remainder of the workshops.

Attendance

The workshops were attended by 208 participants from 6 states. The Northern Territory, while consulted in the early stages of the project, was not represented because stakeholder feedback indicated that falls as an outcome of ageing was not a major issue particularly in Indigenous communities. Stakeholders also felt that the Resource Kit was not appropriate for use with the indigenous community. The following graph shows the participants who attended the workshops by state.

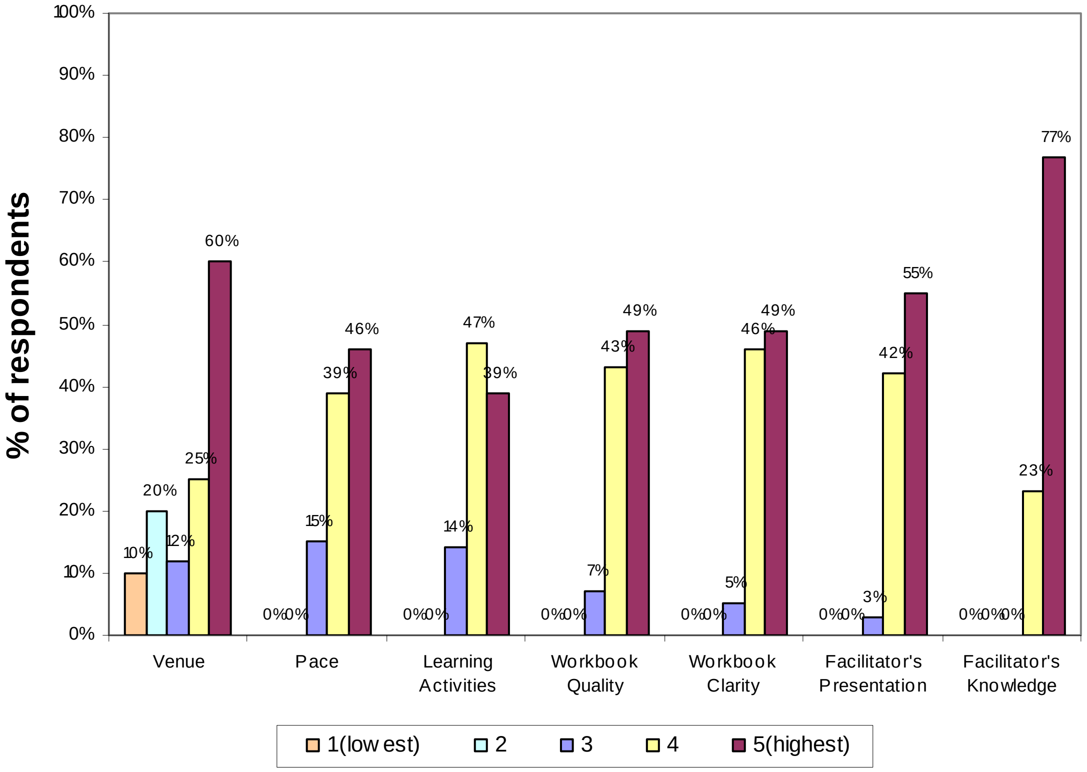


A review of the postcodes of the participants indicates that at least 50% travelled more than 50 kms to attend the Falls Prevention Training. This is significant in regard to both the participant's interest in the training and their management's support of them attending, in some cases being away from their work for 4 -5 days (including travel time).

The majority of participants were Registered Nurses (52%) and Enrolled Nurses (10%). Allied Health Professionals and some service managers made up the remainder (38%). 91% of participants work in a clinical role, with 9% of participants working in a management role.

Workshop Satisfaction

Participants were asked to respond to various aspects of the workshop, ranking each from 1 (lowest satisfaction) to 5 (highest satisfaction).



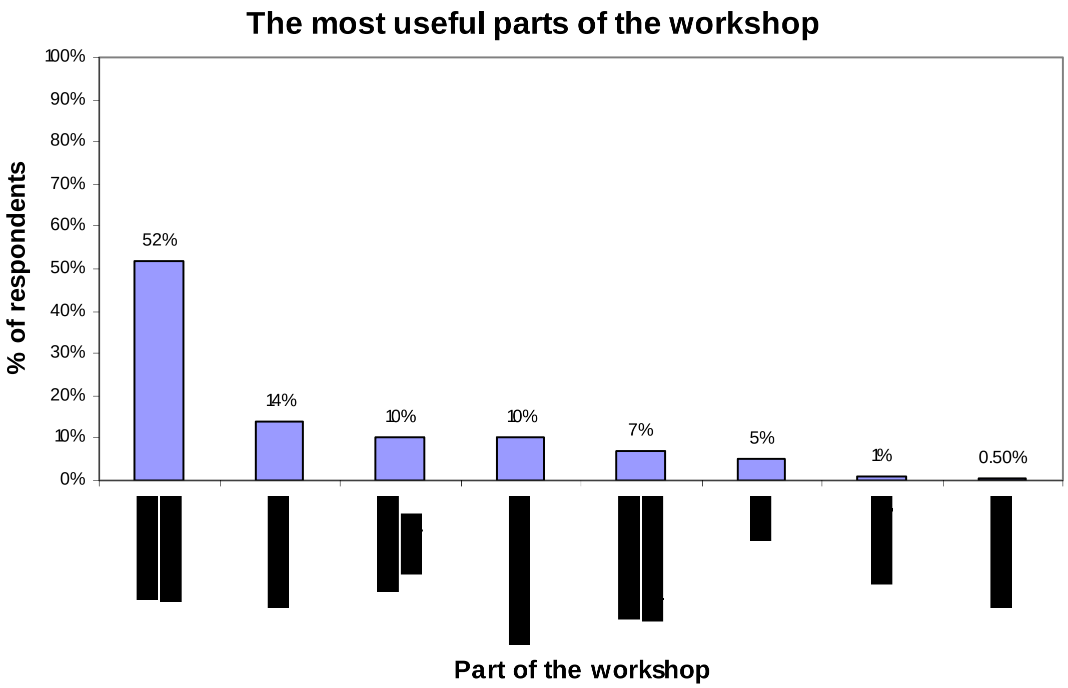
The facilitator's knowledge and presentation of the subject was ranked highly, with 100% and 97% of participants respectively rating their satisfaction in the top two rankings.

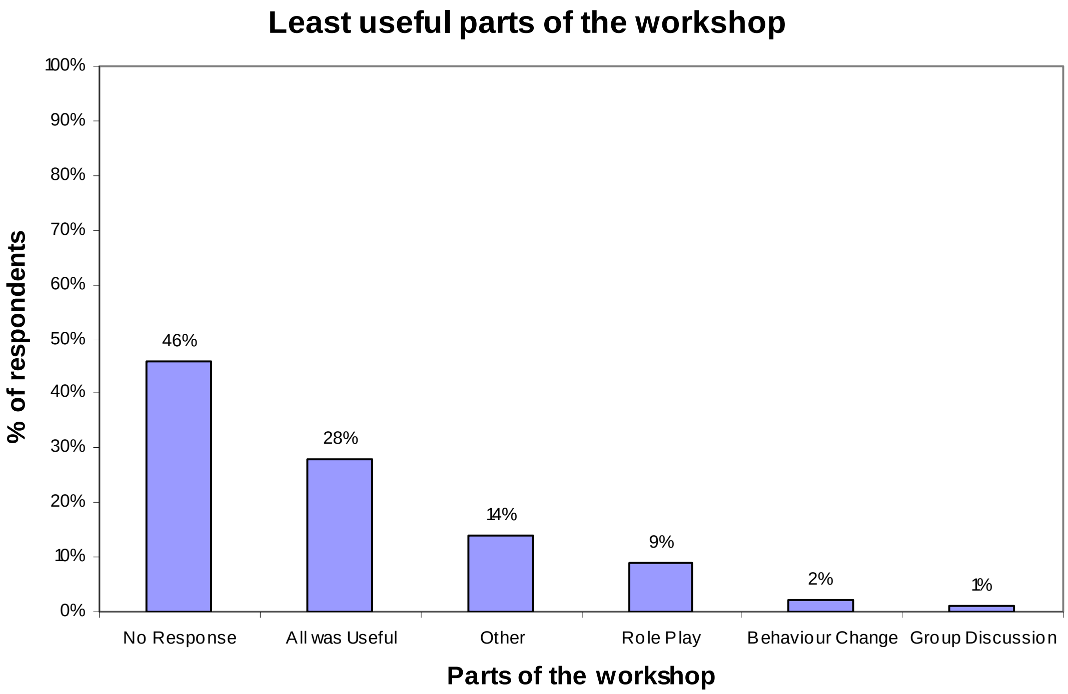
Open Ended Questions

The end of workshop evaluation questionnaire asked participants 6 open ended questions about the most and least useful aspects of the workshop, new skills and knowledge gained, suggested changes for future programs, achievement of expectations and any other comments.

The responses have been grouped into ‘themes’ that have become evident in the data analysis. The dominant themes for each question vary because of the respondents being able to state their personal perspective.

The Most and Least Useful Parts of the Workshop





The most useful part of the workshop program was the administration of the QuickScreen© tool and overall use of the Resource Kit (52%). The least useful part of the workshop was the role play (9%). The reasons provided for this were that it was ‘too lengthy’, ‘not a useful learning experience’ and being ‘daunted by the experience’.

New Skills and Knowledge

The following chart shows the main areas of increased knowledge and skills, with 48% of respondents stating that introduction to the Resource Kit and Quickscreen© Tool was the most significant new skill and knowledge gained from the workshop.

Suggested Changes to the Workshops

Respondents were asked what changes they would introduce to the workshop if they were designing it in future. Of the respondents 45% did not respond to this question, 25% indicated that they would not change anything and 30% provided a variety of suggestions. The suggestions can be ‘themed’ into making the workshop more practical with less theory, more involvement of other (local) professionals and community groups and an indication that some segments of the program were too long.

Participant Expectations

Expectations of the workshop were met by 91% of respondents. Of the remaining 9%, 7% either had no expectations or did not respond to the question.

Additional Comments

- *Great day, well structured, well paced, friendly*

- *Facilitators were very well versed with knowledge*
- *The tool is very useful and easy to use. It would be greatly beneficial for health outcomes. And in terms of funding training for human resource it adds great economic value to health care systems, saving health dollars by preventing falls.*

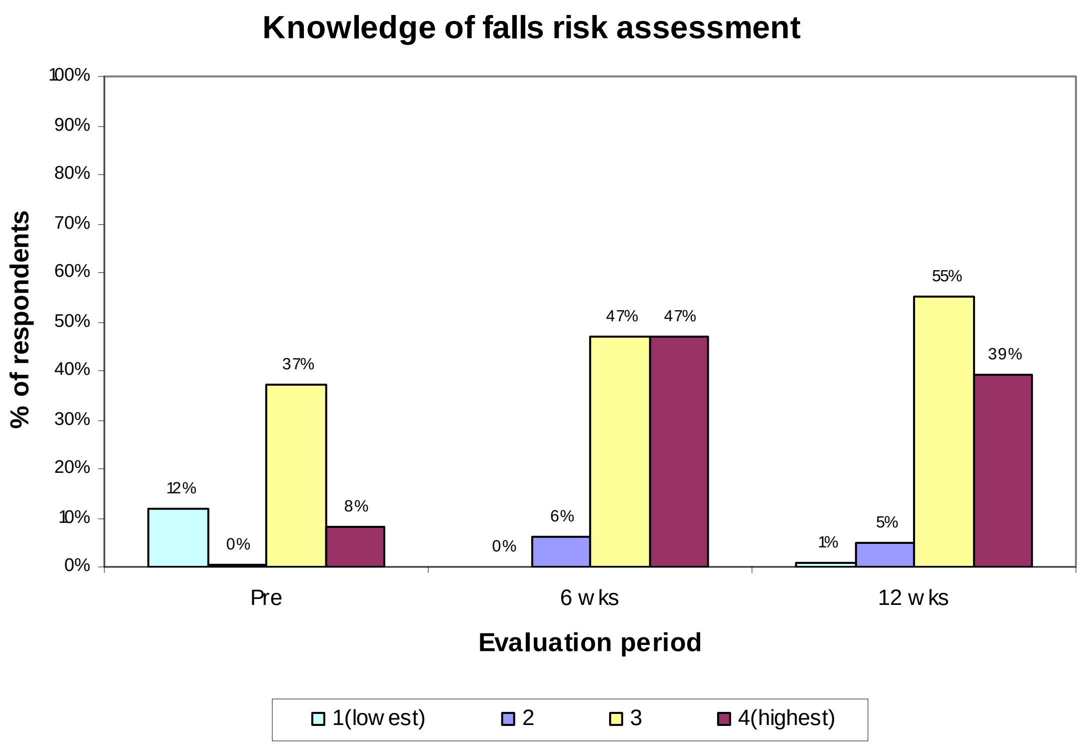
POST WORKSHOP EVALUATIONS

The post workshop evaluations were conducted at 6 and 12 week intervals following each workshop. After a 98% return for the end of workshop evaluations, the post workshop evaluations only drew a 55% return at 6 weeks and 40% return at 12 weeks. In the absence of any other post workshop data, it has been assumed that the changes evident at 6 and 12 weeks are representative of all workshop participants.

A telephone interview evaluation was planned for a random selection of participants to supplement the written post-workshop evaluations but was subsequently abandoned. The rationale for this is unclear.

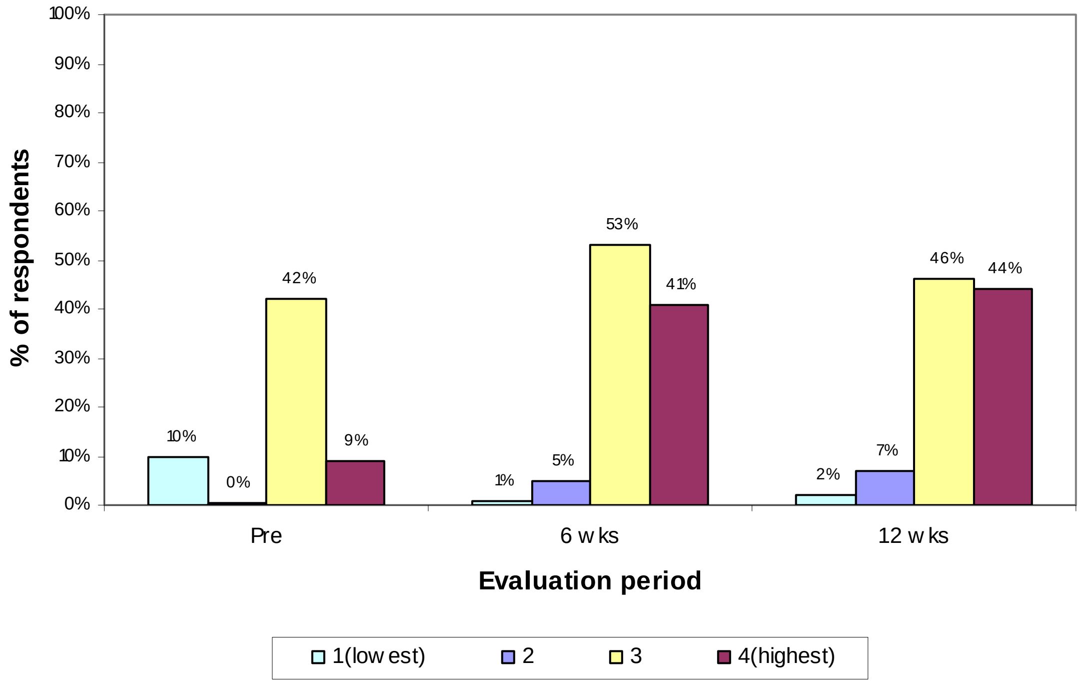
Knowledge, Skills and Confidence

Knowledge, skills and confidence in falls risk assessment and prevention were ranked from 1 to 4 by respondents with 1 being the lowest ranking and 4 the highest, except where otherwise indicated.



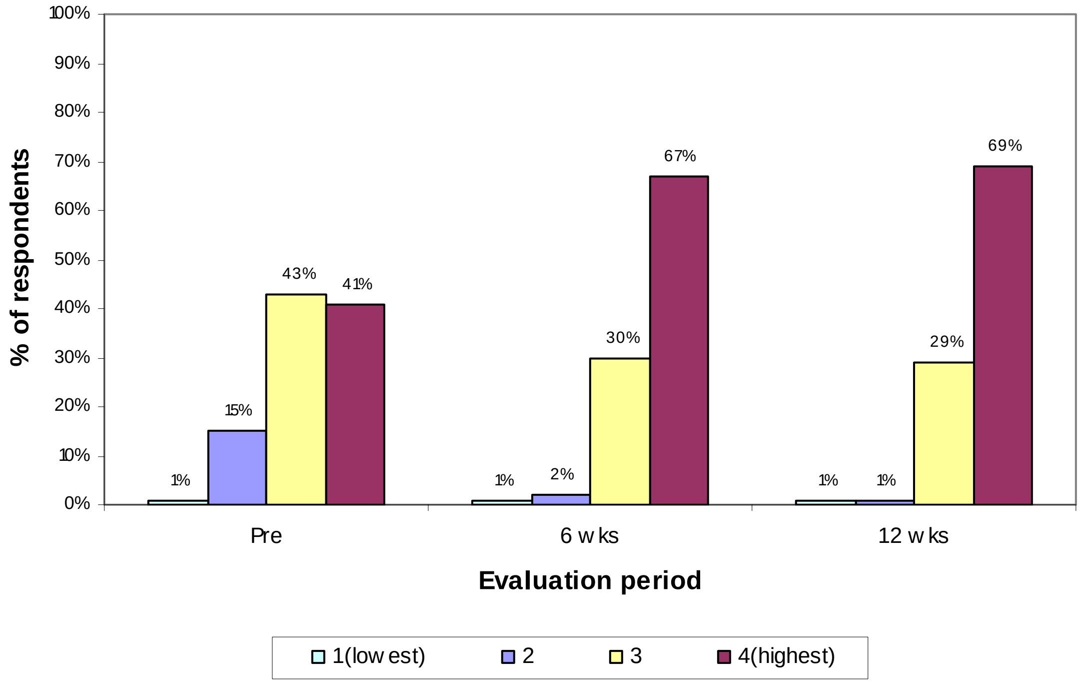
Knowledge of falls risk assessment increased in the top 2 rankings from a pre workshop level of 45% to 94% at 6 weeks and 12 weeks. Even though the top 2 rankings achieved 94%, the highest ranking dropped 8% between the 6 and 12 week evaluations, there is no indication as to why this has occurred.

Knowledge in preventing falls risk



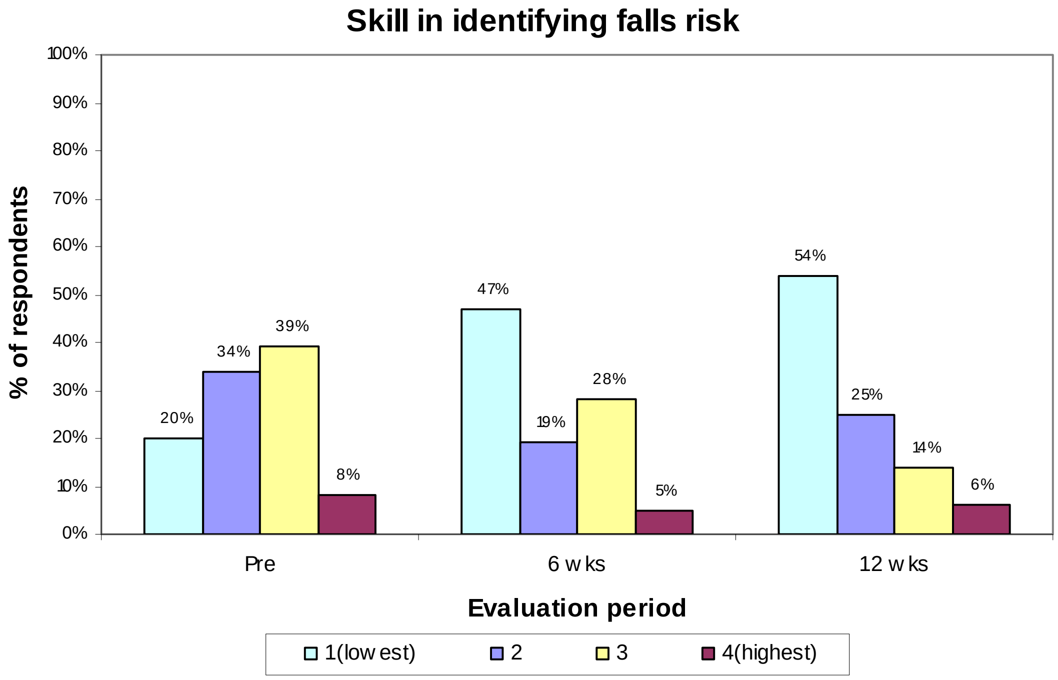
Knowledge in preventing falls risk increased in the top 2 rankings from a pre workshop level of 51% to 94% at 6 weeks but dropped to 90% at 12 weeks.

Understanding of implications of falls

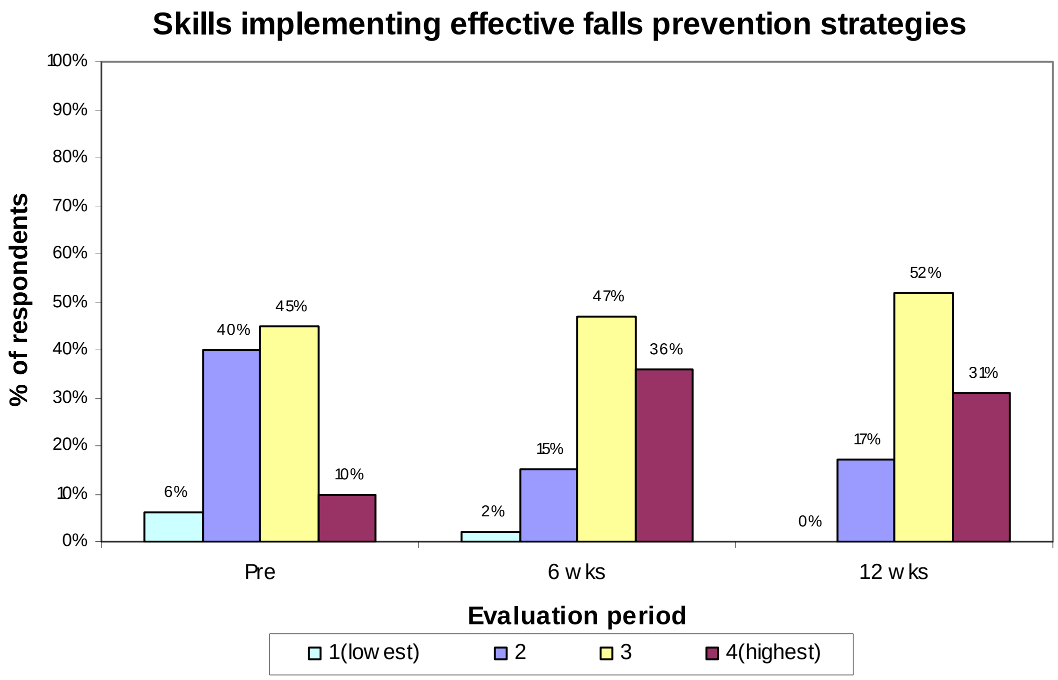


Understanding of the implications of falls increased in the top 2 rankings from a pre workshop level of 84% to 97% at 6 weeks and 98% at 12 weeks.

Overall respondents indicated that their knowledge of falls risk assessment, prevention together with the understanding of the implications of falls had increased following attendance at the workshops.

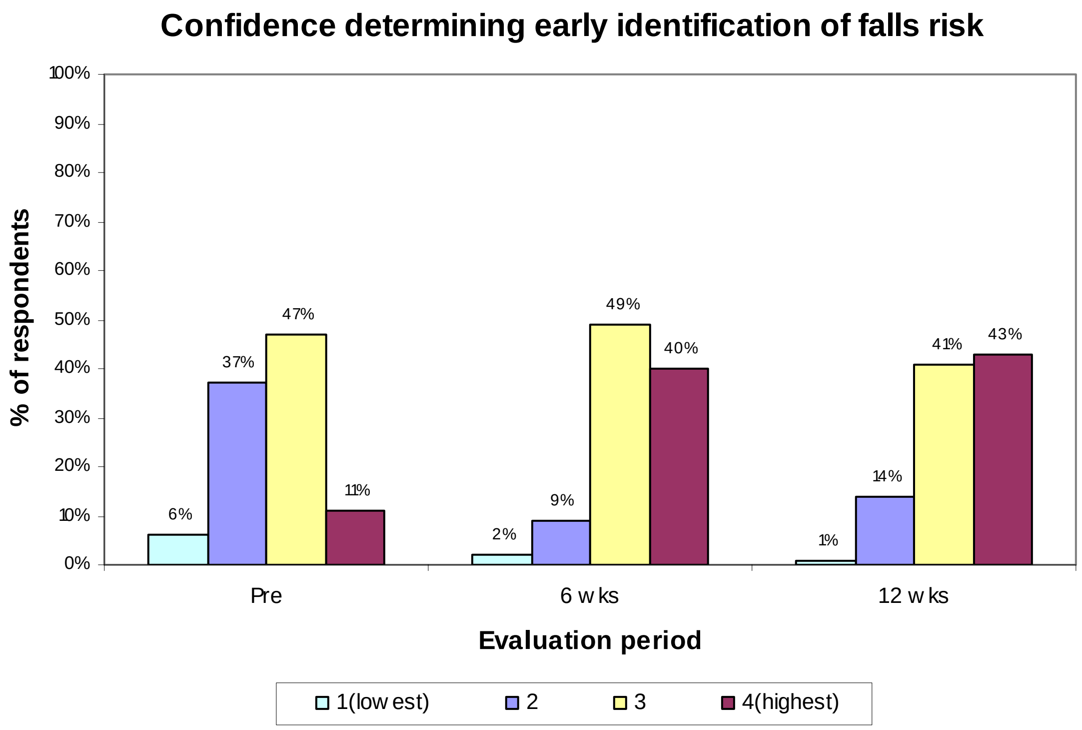


Skills in identifying falls risk were ranked from 1 to 4 by respondents with 1 being the highest ranking and 4 the lowest. This differs from previous questions which were ranked 1: low to 4: high and this may have had some impact on the results. Skill in identifying falls risk increased in the lower 2 rankings from a pre workshop level of 54% to 66% at 6 weeks and 79% at 12 weeks.

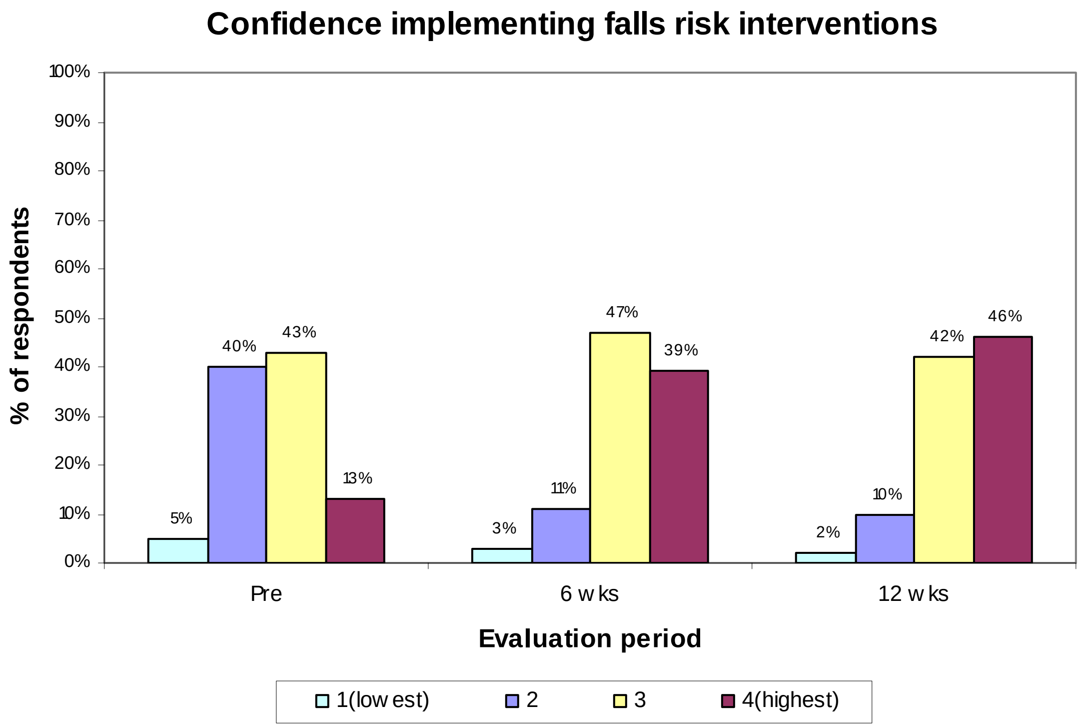


Skills in implementing falls prevention strategies increased in the top 2 rankings from a pre workshop level of 55% to 83% at 6 and 12 weeks. Even though the top 2 rankings achieved 83%, the highest ranking dropped 5% between the 6 and 12 week evaluations. Although there is no documented evidence as to why this drop may have occurred it is possible that it is the result of limited or no access to the Resource Kit during the post workshop period.

Overall participants believed that their skill level in identifying falls risk and implementing effective interventions improved following the workshops.



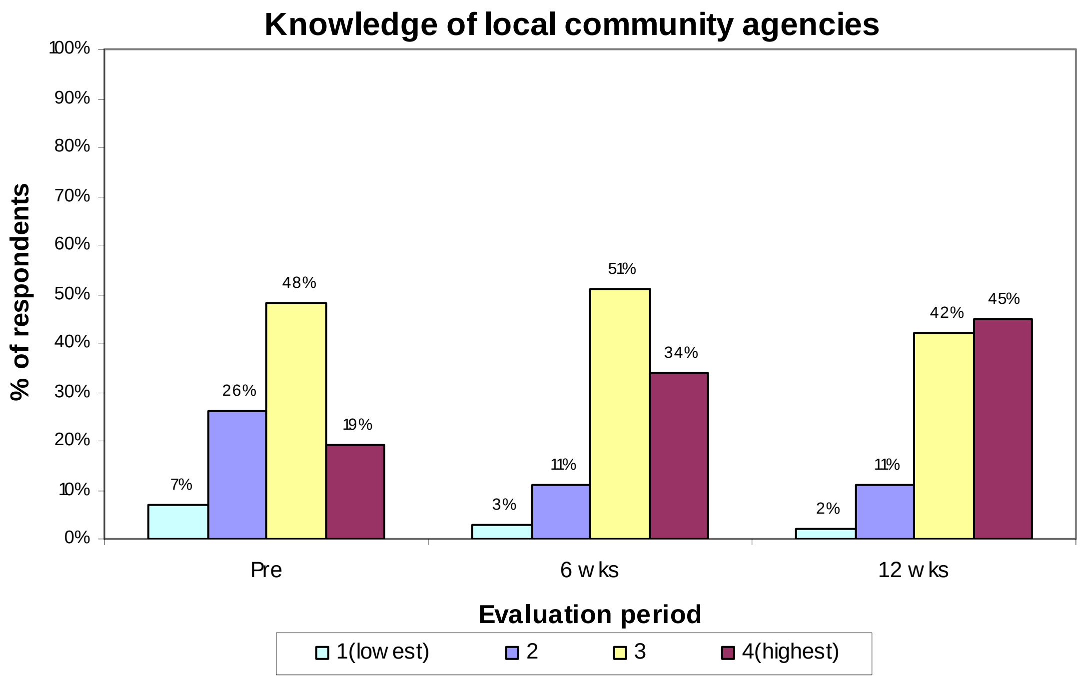
Confidence in determining early identification of falls risk increased in the top 2 rankings from a pre workshop level of 58% to 89% at 6 weeks and dropped to 84% at 12 weeks. There was a consistent overall increase in confidence in early identification of falls risk but there was a slight drop 12 weeks post workshop.



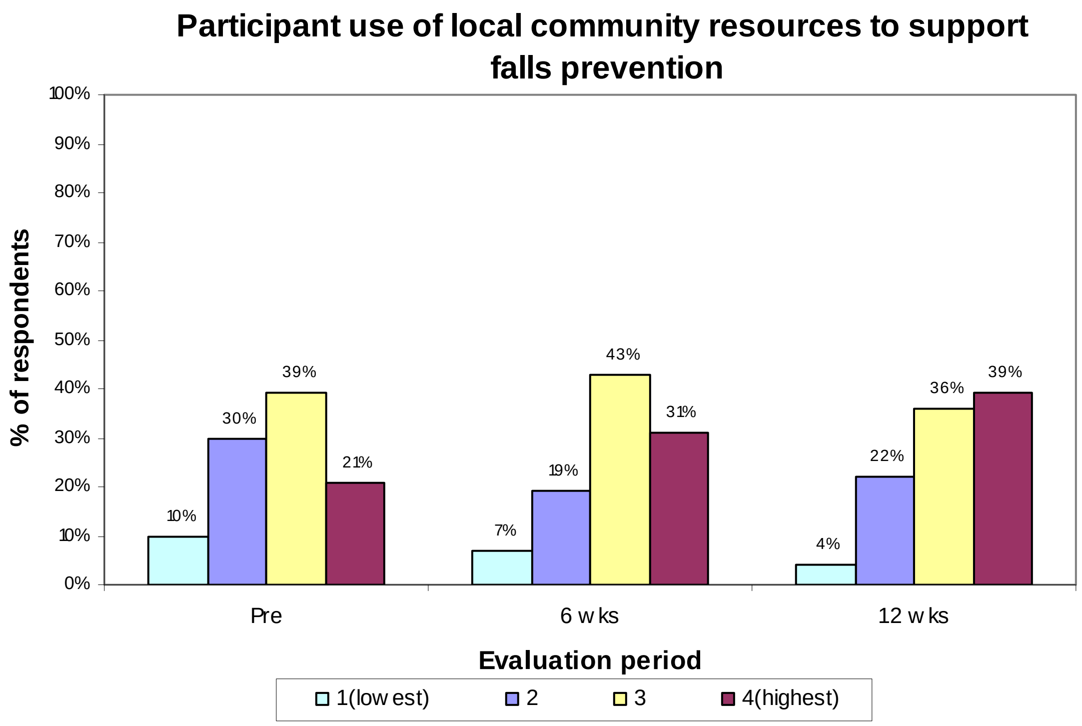
Confidence in implementing effective falls risk interventions increased in the top 2 rankings from a pre workshop level of 56% to 86% at 6 weeks and 88% at 12 weeks.

Working with Community Agencies

It should be noted that 'community agencies' and 'community resources' were used in similar context without providing a definition for each term. This appears to have resulted in some misunderstanding of the questions and thus the participant's responses. For example, 'local community agencies' were seen to be local exercise groups rather than the local Department of Health. This has meant that the second question regarding confidence in working with local agencies has had to be disregarded due to the inconsistency of the question leading to skewed results.



Knowledge of local community agencies increased in the top 2 rankings from a pre workshop level of 67% to 85% at 6 weeks and 87% at 12 weeks.



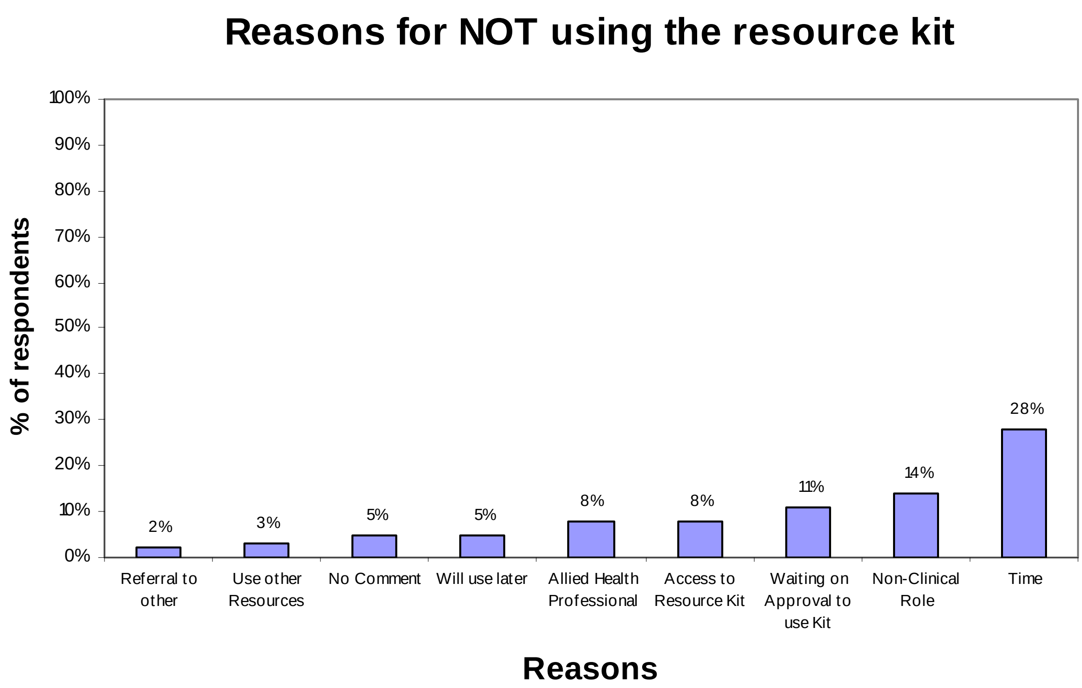
Use of local community resources to support falls prevention increased in the top 2 rankings from a pre workshop level of 60% to 74% at 6 weeks and 75% at 12 weeks. Again, the greatest improvement occurred in the highest ranking where in the pre-workshop percentage of respondents who used local agencies to support falls prevention improved from 21% to 39% at 12 weeks post workshop.

Access to and Use of the Resource Kit

Access to Resource Kit	6 weeks	12 weeks
Yes	95%	93%
No	5%	7%

Respondents who have access to the Resource Kit and who have used any part or parts of the kit:

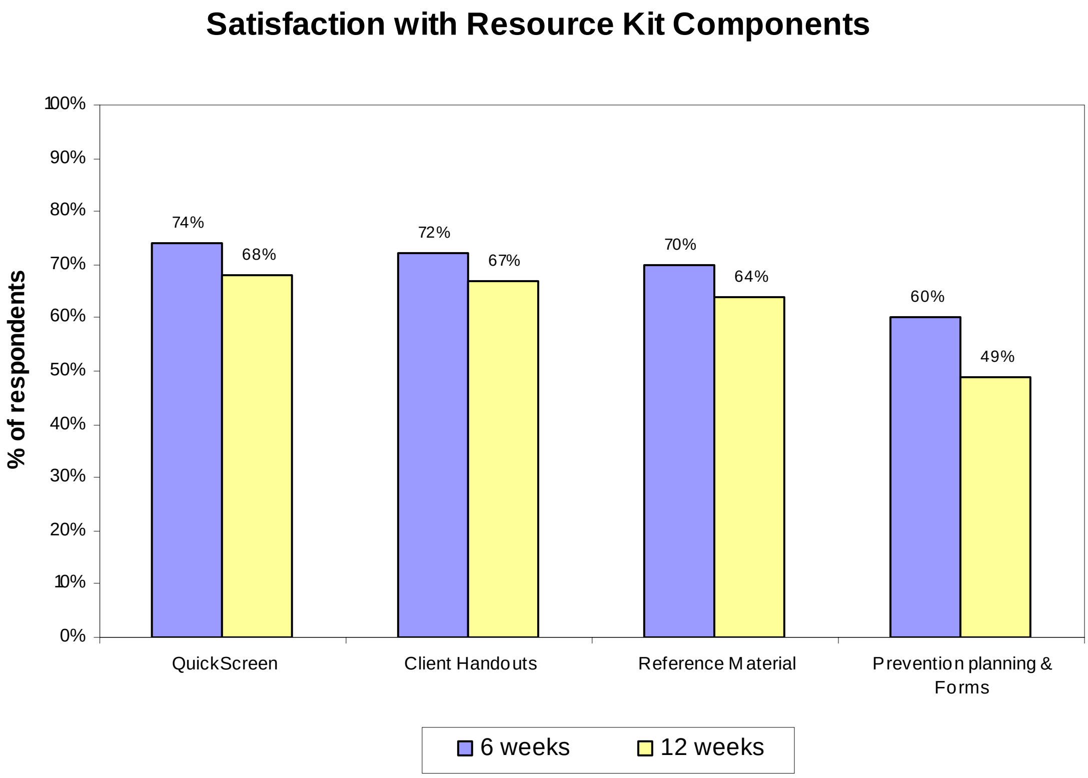
Have used parts of the Resource Kit	6 weeks	12 weeks
Yes	65%	72%
No	35%	28%



The primary reason (28%) that the resource kit was accessible but not used was the lack of time to conduct the assessment due to existing workloads or lack of time to familiarise themselves with the kit prior to using it in a clinical setting.

A significant percentage of respondents (11%) were waiting for management approval before using the Resource Kit and access to the Resource Kit affected 8% of respondents. Hence a total of 19% of respondents were unable to use the kit even though they were ready to do so. Improved access to more Resource Kits will be addressed through the project at a later date.

Satisfaction with Resource Kit and Quickscreen© Tool

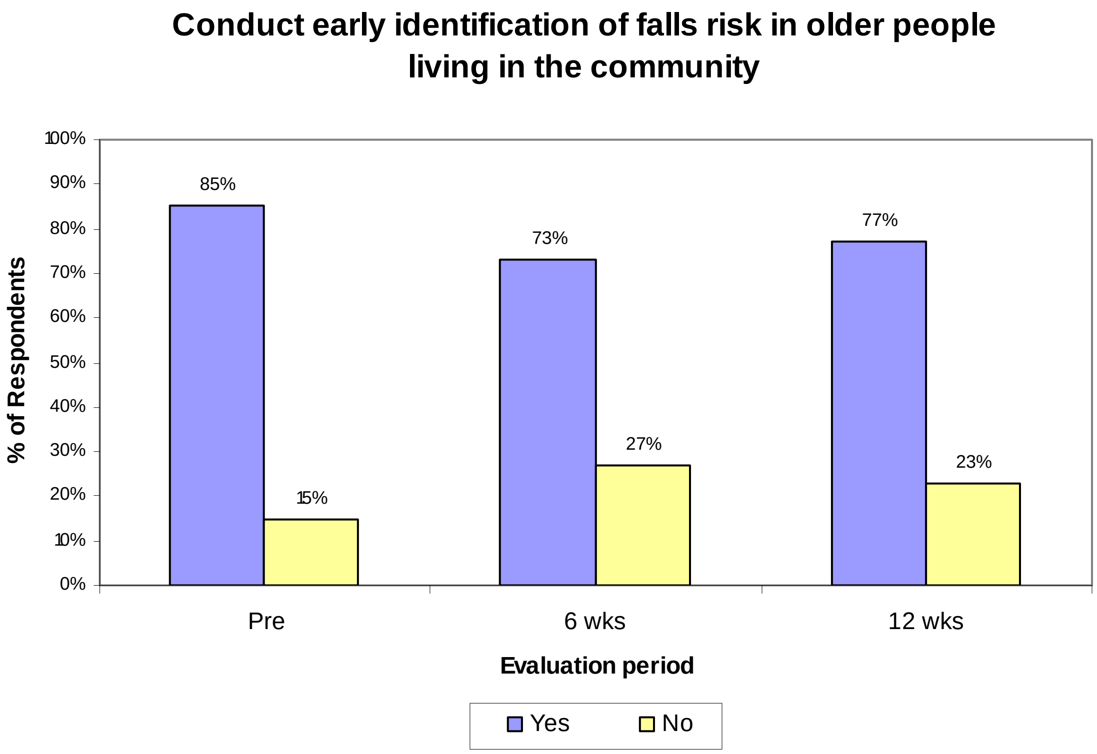


Satisfaction with all components of the Resource Kit declined between 6 and 12 weeks post workshop. It would have been beneficial to explore this question further so as to provide an insight into why satisfaction levels have declined.

Changes to Clinical Practice

Respondents were asked to report if they were aware of any changes to their clinical practice as a result of attending the workshop. Of the respondents 59% reported a change in their practice at 6 weeks and 58% at 12 weeks post workshop. It should be noted that some respondents reported a change in their clinical practice even though they do not conduct early identification of falls risk. Of the reported change, the primary changes were increased awareness of risk factors and improved assessment skills resulting in earlier identification of falls risk.

Early Identification of Falls Risk in Older People in the Community

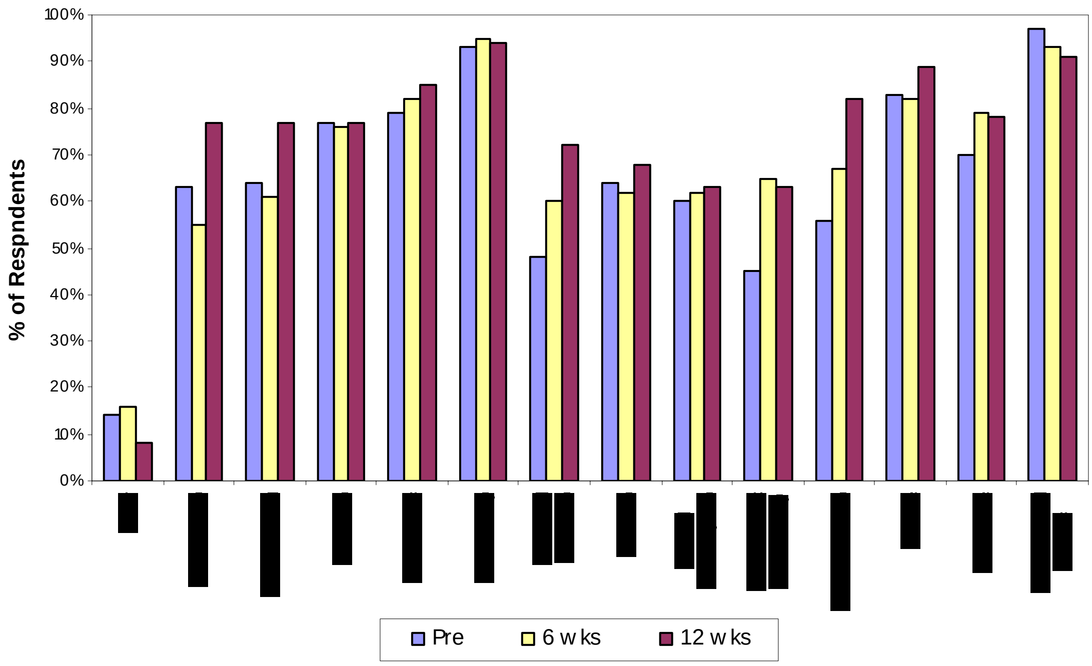


There was an overall decrease in respondents conducting early identification of falls risk in older people. There was no request for supporting information from those who do not conduct early risk identification in older people; hence the cause for this decrease from 85% to 77% is not known. There may have been an increase in the respondents understanding of what comprises early identification and this knowledge has influenced their response, that is, what was originally viewed as early identification at the pre-workshop questionnaire was not seen as early identification following the skills and knowledge gained during the workshops.

Those who conduct early identification of falls risk with older people living in the community were asked to expand on which factors they include in their assessment.

Factors Included in Early Identification of Falls Risk

Factors Included in Early Identification of Falls Risk



The factors with the greatest increase in inclusion in early identification were muscle strength (26% increase), peripheral sensation (24% increase) and low contrast visual acuity (18% increase). These three factors relate specifically to the tools provided in the Resource Kit: the ‘near tandem stand test’, the ‘tactile sensitivity test’ and the ‘low contrast visual acuity test’.

The remaining factors showed a less than 10% increase between the pre-workshop questionnaire and the post workshop evaluations.

DISCUSSION

The planning and logistics for the implementation of the Falls Prevention Project were daunting and the Project Officer must be commending on an outstanding effort. Overall, the workshops were successful in achieving their aim of enabling participants to be:

> *'more confident and competent in earlier identification of falls risk and prevention and thereby increase falls risk assessment and prevention interventions'*.

The Project Officer resigned from the AARN position before the return of the 12 week post-workshop questionnaires. This has meant that this report is purely a collation of the data, with limited personal observation or anecdotal input.

The following points of discussion highlight the achievements and areas for consideration in future workshops.

1. The distance over 50% of participants travelled to attend the workshops and the 'in kind' support in both time and money to local health services for participants to attend is remarkable, especially in areas where health professionals are at a premium. It appears that professional development for staff in rural and remote areas is valued and that prevention of and early identifications of falls risk is valued within many communities.

2. It was interesting to note that most of the participants were required to conduct falls risk assessments, yet very few had been trained to do so in the previous twelve months. Training done prior to the previous twelve months was not recorded but with the effort expended by most local health services to get many of the participants to the workshops it can be assumed that most had not received adequate training prior to these workshops.

3. The pre-workshop questionnaire identified that a range of falls assessment tools are currently being used in rural areas. This could lead to inconsistency in the assessment of falls risk and the implementation of early intervention strategies across rural communities and area health services. The use of the *Quickscreen*© Tool and Resource Kit could rectify these inconsistencies.

4. Overall there was an increase in skills, confidence and knowledge regarding early identification and prevention of falls risk from participation in the workshops. This is particularly evident in the factors used to conduct early identification of falls risk. The factors with the greatest increase were those specific to the *Quickscreen*© Tool, incorporated into the Resource Kit.

5. The most useful part of the workshops was learning to use the *Quickscreen*© Tool and Resource Kit. It appears that where health professionals are restricted in time and resources, a tool that can assist them in their care of their community is valuable. Although health promotion theory is an integral part of such workshops participant responses indicated that the theoretical component of the workshops was too long. Keeping the theoretical component of any future workshops should be succinct. Providing pre-reading material for participants and a brief recap during the workshop may be a solution to this issue.

6. The post-workshop evaluations were long and convoluted, leading to some questions being misinterpreted by participants. Collating the data proved to be a complex task due

to the sequencing of the questions. A simple questionnaire would have elicited concise data as to the value and success of the workshops and Resource Kit.

7. The response rate for the 6 and 12 week evaluations dropped 99% for the pre-workshop questionnaire to 40% by the 12 week post-workshop evaluation. It was unfortunate that the telephone interviews were abandoned by the Project Officer. It is not known why this happened but it is apparent that information gleaned from these could have explained some of the unexpected data in the post-workshop questionnaires.

CONCLUSION

Overall, the Falls Risk Projects was successful in increasing the skills, knowledge and confidence of health professionals, particularly nurses, in rural Australia. The Resource Kit, incorporating the *Quickscreen*© Tool, is a valuable resource in preventing falls risk in rural communities. As with all health promotion projects, there are valuable lessons to be learned from this project, particularly from the post-workshop evaluation, to ensure greater success in taking health promotion to rural health workers.

Deb Cook
Evaluation Consultant
November 2005

RCNA General Practice Nurse Workshop – Falls Prevention & Assessment Education
Master Pre & Post Workshop Survey

Total number of delegates that filled out Pre-workshop survey: 87
Total number of delegates that filled out Post-workshop survey: 34

The Major cause of death in the over 65s is? (Pre)

Answer	**Response**	**Response**
Old Age	4%	3
Falls	70%	55
Myocardial Infarction	24%	19
Cancer	2%	2
Total Respondents		**79**
(skipped this question)		*8*

The Major cause of death in the over 65s is? (Post)

Answer	**Response Percent**	**Response Total**
Old Age	4%	2
Falls	96%	32
Myocardial Infarction	0%	0
Cancer	0%	0
Total Respondents		**34**
(skipped this question)		*0*

Falls are a normal part of ageing? (Pre)

Answer	**Response Percent**	**Response Total**
Strongly disagree	62%	50
Unsure	7%	5
Strongly agree	31%	25
Total Respondents		**80**
(skipped this question)		*7*

Falls are a normal part of ageing? (Post)

Answer	**Response Percent**	**Response Total**
Strongly disagree	94%	31
Unsure	3%	1
Strongly agree	3%	1
Total Respondents		**33**
(skipped this question)		*1*

Falls cannot be prevented. (Pre)

Answer	Response Percent	Response Total
Strongly disagree	82%	70
Unsure	1%	1
Strongly agree	17%	14
Total Respondents		**85**
(skipped this question)		*2*

Falls cannot be prevented. (Post)

Answer	Response Percent	Response Total
Strongly disagree	94%	32
Unsure	0%	0
Strongly agree	6%	2
Total Respondents		**34**
(skipped this question)		*0*

How many falls risk assessments have you preformed in the past 4 weeks? (Pre)

Answer	Response Percent	Response Total
>20	2%	2
16-20	1%	1
11-15	1%	1
6-10	6%	5
1-5	38%	31
0	52%	42
Total Respondents		**82**
(skipped this question)		*5*

How many falls risk assessments have you preformed in the past 4 weeks? (Post)

Answer	Response Percent	Response Total
>20	3%	1
16-20	0%	0
11-15	6%	2
6-10	6%	2
1-5	61%	20
0	24%	8
Total Respondents		**33**
(skipped this question)		*1*

Fear of falling is major risk factor. (Pre)

Answer	Response Percent	Response Total
Strongly disagree	6%	5
Unsure	7%	6
Strongly agree	87%	73
Total Respondents		**84**
(skipped this question)		*3*

Fear of falling is major risk factor. (Post)

Answer	Response Percent	Response Total
Strongly disagree	9%	3
Unsure	0%	0
Strongly agree	91%	30
Total Respondents		**33**
(skipped this question)		*1*

A multi factorial intervention program in falls prevention has greater impact than a single factor program? (Pre)

Answer	Response Percent	Response Total
Strongly disagree	15%	12
Unsure	12%	10
Strongly agree	73%	58
Total Respondents		**80**
(skipped this question)		*7*

A multi factorial intervention program in falls prevention has greater impact than a single factor program? (Post)

Answer	Response Percent	Response Total
Strongly disagree	7%	3
Unsure	0%	0
Strongly agree	93%	31
Total Respondents		**34**
(skipped this question)		*1*

Health professionals that can be utilised in the referral process for falls prevention include: (Pre)

Answer	**Response Percent**	**Response Total**
Aboriginal Health Wk	74%	63
Meals on Wheels	32%	27
Optometrist	76%	65
Podiatrist	85%	72
Dietitian	65%	55
Courier	8%	7
Community Nurse	96%	82
Physiotherapist	100%	85
Hairdresser	10%	9
Total Respondents		**85**
(skipped this question)		*2*

Health professionals that can be utilised in the referral process for falls prevention include: (Post)

Answer	**Response Percent**	**Response Total**
Aboriginal Health Wk	77%	24
Meals on Wheels	57%	19
Optometrist	93%	29
Podiatrist	100%	31
Dietitian	97%	30
Courier	12%	4
Community Nurse	100%	31
Physiotherapist	100%	31
Hairdresser	16%	5
Total Respondents		**31**
(skipped this question)		*3*

I am familiar with & have utilised the Education Package CD-ROM since the workshop? (Post only)

Answer	**Response Percent**	**Response Total**
Yes	63%	19
No	37%	11
Total Respondents		**30**
(skipped this question)		*4*

Have you successfully completed the assessment part of the education package? (Post only)

Answer	**Response Percent**	**Response Total**
Yes	53%	16
No	47%	14
Total Respondents		**30**
(skipped this question)		*4*

If your answer is no is there any reason? (Post only)

- Lack of time

I am familiar with and utilise the Falls Risk Assessment Framework? (Pre only)

Answer	**Response Percent**	**Response Total**
Yes	16%	14
No	84%	69
Total Respondents		**83**
(skipped this question)		*4*

I am familiar with and utilise the Quick Screen Assessment Tool? (Pre)

Answer	**Response Percent**	**Response Total**
No	78%	32
Yes	22%	9
Total Respondents		**41**
(skipped this question)		*46*

I am familiar with and utilise the Quick Screen Assessment Tool? (Post)

Answer	**Response Percent**	**Response Total**
No	36%	11
Yes	64%	19
Total Respondents		**30**
(skipped this question)		*4*

If your answer is yes, how often do you use the tool? (Post only)

Answer	Response Percent	Response Total
Less than once a Mth	37%	7
On to two times a Mth	26%	5
Once a week	10%	2
Several times a week	16%	3
Once a day	0%	0
More than once a week	10%	2
Total Respondents		**19**
(skipped this question)		*15*

On average how many older patients visit the practice that you work at each month? (Post only)

Answer	Response Percent	Response Total
>151	33%	14
101-150	0%	1
51-100	33%	7
1-50	33%	5
Total Respondents		**27**
(skipped this question)		*7*

On average how many older patients visit the practice that you work at as a result of falls each month? (Post only)

Answer	Response Percent	Response Total
>76	5%	1
51-75	0%	0
26-50	10%	2
1-25	85%	16
Total Respondents		**19**
(skipped this question)		*15*

Are you more confident in undertaking falls risk assessments in older people since attending the workshop? (Post only)

(skipped this question) *18*

Answer	Response Percent	Response Total
Highly not confident	0%	0
Not confident	6%	1
Confident	88%	14
Highly confident	6%	1
Total Respondents		**16**

After attending the workshop do you feel that general practice nurses can contribute to falls prevention for older people? (Post only)

Answer	**Response Percent**	**Response Total**
Yes	100%	32
No	0%	0
Total Respondents		**32**
(skipped this question)		*2*

Did you feel that the workshop was a benefit to your practice and has improved your skills in falls prevention? (Post only)

Answer	**Response Percent**	**Response Total**
Yes	97%	31
No	3%	1
Total Respondents		**32**
(skipped this question)		*2*

Research papers that have arisen from this thesis

Tiedemann A, Sherrington C, Lord S. Physiological and psychological predictors of walking speed in older community dwelling people. Gerontology 2005; 51: 390-395.

Lord S, Murray S, Chapman K, Munro B, **Tiedemann A**. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. Journals of Gerontology Series A-Biological Sciences & Medical Sciences. 2002; 57: M539-M543.

Tiedemann A, Sherrington C, Lord S. Physical and psychological factors associated with stair negotiation performance in older people. Submitted to Journal of Gerontology: Medical Sciences, September 2006.

Tiedemann A, Shimada H, Sherrington C, Murray S, Lord S. The comparative ability of eight functional mobility tests for predicting falls in community-dwelling older people. Submitted to Age and Ageing, November 2006.