School of Physiotherapy and Exercise Science

Fall Risk Assessment and Effectiveness of Home Based Exercise on Balance and Functional Mobility among Malaysian Adult Aged 50 years and above

Asmidawati Ashari

This thesis is presented for the Degree of

Doctor of Philosophy

of

Curtin University

April 2017

DECLARATION

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

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

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval number PT213/2013.

Signature: ……………………………

Date: 5 April 2017

STATEMENT OF ORIGINALITY

This thesis is presented for the degree of Doctor of Philosophy at Curtin University, Western Australia. Studies were undertaken between October 2012 and October 2015, through the School of Physiotherapy and Exercise Science at Curtin University, Western Australia, in association with the Institute of Gerontology, Universiti Putra Malaysia.

All of the material presented in this thesis is original. This program of research was developed in association with my supervisors who have been involved in editing both this thesis and all associated publications.

ABSTRACT

Falls are a major public health problem for older people worldwide. Although there are many studies of falls risk factors and falls prevention interventions, the majority of these have been undertaken in Western countries. Recently, there is growing evidence of differences in some risk factors and acceptability of some interventions between countries and cultures that mean that data on risk factors and effective interventions cannot necessarily be translated between countries. Malaysia is projected to become an aged nation by year 2035. This demographic change sees older people forming a more significant part in the Malaysian society. This situation creates the need for preventive action to minimize the impact of the problems associated with ageing, such as falls. Therefore, the magnitude of the problem of falls and associated contributory factors needs to be defined in the Malaysian context, and management strategies should be designed within the context of local needs and the Malaysian primary and public health care systems. Studies presented in this thesis aimed to provide a basis for planning falls prevention interventions of relevance to specific identified risks in the Malaysian population. The main objective is to identify the prevalence of falls, balance impairment and contributory falls risk factors among community dwelling adults aged 50 years and above in Malaysia, and to use this data to develop and evaluate the effectiveness of a targeted exercise program to improve common balance impairments in community dwelling adults aged 50 years and above in Malaysia.

A cross-sectional study was conducted using convenience sampling, with retrospective recall of falls in the past 12 months as the primary measure (study 1). Participants were recruited from the membership of the University of Third Age (U3A) of Malaysia, on a voluntary basis. Participants underwent a comprehensive assessment of falls risk factors and balance impairment.

A total of 156 participants were recruited, with more than half of the participants (56%) being females. The age of participants ranged from 50 to 78 years old, with median age being 63.0 years (IQR = 6.5). The majority of the participants were Malays (83.3%), most were married (76.3%), 81% were not working and 6.4% lived alone. Forty nine (31.0%) participants fell, with 26.6% experiencing one fall and 4.4% having two or more falls within the previous twelve months from the date of interview. Trip and slip were the most prevalent cause of falls, accounting for 76% of falls. More

than half (55%) of falls occurred in the afternoon and while participants walked inside the home (32.7%), outside home (30.6%), and 36.7% were in community areas. Among those who fell, it was noted that 40 (82%) suffered injuries and 18 (37%) required medical treatment and 6.1% reported a severe injury such as fracture or dislocation. A major finding indicated more than half (84%) of participants had balance impairment during turning. Three measures of balance and mobility were significantly different between fallers and non fallers. Fallers showed slower walking speed, more sway during turning, took longer time to turning and poor single limb stance. Multiple regression analysis showed that the visual contrast sensitivity, back pain, and turning sway were significantly associated with fall, and accounted for 71.8% of the variance of risk factors. A Two-way ANOVA indicates there were no differences for fall risk factors between gender and three age groups (50-59, 60-69, and 70 years and above). Interestingly, the present study found that the younger age group had more falls than older age group. Factor analysis was used to determine an abbreviated suite of measures for future research and clinical practice. Study results indicated that four factors incorporating static (static stance) and dynamic (turning and leaning) components would be recommended when assessing balance and mobility performance.

Results from the cross-sectional study were used to develop and evaluate the effectiveness of a targeted exercise program to improve common balance impairments, including the turning impairment identified in the previous study, in community dwelling adults aged 50 years and above in Malaysia. A single blind randomised controlled trial was conducted involving community-dwelling aged 50 years and over, who were identified in study 1 to have impairments of balance during turning. A 16 week home based exercise program with a focus on exercises aiming to improve turning was used for the intervention group (a specific focus on turning exercises were used based on the results of study 1), while the control group maintained their usual activities. A two way repeated measures ANOVA indicated significant interaction effects for turning and balance/mobility measures. The intervention group significantly improved relative to the control group for (1) sway when turning 180 degrees, $F(1,65)=8.653$, $p=0.005$), (2) time to perform 180 degree turn, $F(1,65)=8.903$, $p=0.004$), (3) Timed Up and Go (TUG) (single task) ($F(1,65)=6.174$, $p=0.016$), (4) TUG (dual task) ($F=8.124$, $p=0.006$), and (5) static stance sway ($F= 11.614$, $p=0.001$). The study also highlighted that participants in the intervention group with high exercise adherence had a significantly better improvement on turning sway performance than those with lower adherence.

The findings presented in this thesis provide insight into the circumstances, consequences and correlates risk of falls in the Malaysian context, and highlights that falls are a common problem among community dwelling Malaysians over the age of 50 years. Results also highlighted that one of the main factors differentiating fallers from non fallers that has rarely been investigated in the past is unsteadiness during turning activities, and this risk factor warrants further investigation in terms of contributory factors and potential interventions. In accordance, an individualized home exercise program that included specific exercises to improve turning ability was found to be effective in improving turning performance in older adults. The study findings highlight the need for a strong focus on fall prevention in the primary healthcare system and implementing culturally appropriate and effective fall prevention programs in Malaysia.

ACKNOWLEDGEMENTS

First and most importantly, I would like to express my greatest gratitude to ALLAH the Merciful, who provided me grace and strength in undertaking this study and towards thesis completion. My PhD journey would not be possible without the endless support, generous encouragement and priceless guidance from some wonderful people.

I would like to express my deepest appreciation and gratitude to my primary supervisor, Professor Keith Hill for his incredible dedication and commitment in providing precious guidance, support and thoughts throughout the PhD journey. It's been a privilege being supervised and to be working with someone so experienced, knowledgeable and understanding like him. I hope this is not the end but a starting point for us to have continued cooperation for future projects.

I would like to thank my associate supervisor, Professor Dr. Tengku Aizan, Director of MyAgeing™ (previously known as Institute of Gerontology), Universiti Putra Malaysia. I am grateful and greatly appreciate her tremendous encouragement and for giving me this golden opportunity to develop my knowledge in 'falls research. In particular, her expertise, advice and site supervision, provision of research facilities during data collection and her valuable feedback on my research project.

My sincere thanks to all my participants from U3A Malaysia. I was very fortunate and it was a pleasure to have such supportive and committed people. This research would not have been possible without them. I pray for my participants' good health. Special thank you to my fantastic research assistants, Farihah Che Man and Siti Norehan Idrus, for their assistance during recruitment and assessment of my participants as well as for their dedicated work that allowed for quality data.

I am indebted for the research facilities provided by the Institute of Gerontology and financial funding granted from Universiti Putra Malaysia for my research activities. I am very fortunate to be surrounded by a supportive group staffs and colleagues who were always there to lend a helping hand during my data collection. Sincerely and heartfelt thanks to all of you. I also would like to express my acknowledgement to Universiti Putra Malaysia and Ministry of Education of Malaysia for their generous scholarship, and Economic Planning Unit, Department of Prime Ministry of Malaysia for allowing me to conduct my PhD research in Malaysia.

I would like to express my gratitude to Associate Professor Dr. Kathy Briffa as a postgraduate coordinator of Research and Chairman of Supervisory committee for her guidance and advice. Special thanks goes to all staff at School of Physiotherapy and Exercise Science for their support throughout my candidacy, especially Janet Hutson, who always made an effort to organize the supervisory meeting.

Not to forget, a million thanks goes to Mr Rudy Adrie Idris, former Malaysian Education Consulate and his wife, Ms Mas Anum Samiran, for your priceless help, care and support during my relocation and treating me like family, sharing sweet moments, celebrating Eid together while we were in Perth. May God reward your kindness. My appreciation to all my friends at HDR hub namely, Nadia, Linda Kohng, Shamala, Josephine, Asrath, Fatim and Margaret who were always there to share our research's experience. I wish you all the best and please keep in touch. Not to forget, my sincere thanks to my fellow friends, Dr. Plaiwan Suttanon, Dr. Claudia Meyer and Dr. Frances Batchelor, whom I met at National Ageing Research Institute (NARI), Parkville, Melbourne. It was a priceless opportunity to know all of you.

Finally, this thesis is dedicated to my beloved family. A special appreciation to my lovely husband, Dr. Rozihan Mohamed, who showered me with limitless love, care, patience, understanding and support. Millions thank for your willingness and sacrifices to become a *"travel man"* travelling to Perth from Malaysia and vice versa. Thank you for your support and allowing me to focus full time towards completion of my thesis. To my beloved children, Alif Rezza, Nureen Aisyah Rezza and Ashraf Rezza, it was a precious moment to be with you over the weekend with hugs and kisses. Thank you very much for your patience and understanding that "*Mama is always at Hub*". Special thanks to my dear cousin Norfaziana Ismail who always willing and patiently looked after my children when I was away from home. Last but not least, I deeply thank my beloved Abah, Hj. Ashari Yussof and Mama, Hjh. Hamidah, Ayah and my late mother in law, Allahyarhammah Napisah Ismail, my siblings, Mira, Mizi, Hisham and Kimi for your unconditional love and prayers. Thank you.

LIST OF PUBLICATIONS AND PRESENTATIONS

Ashari, A., Hamid, T.A., Hussain, M.R., and Hill, K.D. (2014). Home based exercise to improve turning and mobility performance among community dwelling older adults: protocol for a randomised controlled trial. *BMC Geriatrics, 14*(1), 100-109.

Ashari, A., Hamid, T.A., Hussain, M.R., and Hill, K.D. (2016). Effectiveness of individualized home based exercise on turning and balance performance among adults older than 50 years: A randomized controlled trial. *American Journal of Physical Medicine Rehabilitation, 95*(5), 355-365.

Ashari, A., Hamid, T.A., Hussain, M.R., and Hill, K.D. Individualised home based exercise intervention to improve turning performance among older adults: Adherence does matter? Paper presented at International Association of Gerontology and Geriatrics conference, Chiang Mai, Thailand, 21 -26 October 2015.

Ashari, A., Hamid, T.A., Hussain, M.R., and Hill, K.D. Does individualised home exercise improve turning performance among older adults? Paper presented at 6th Biennial Australian New Zealand Fall Prevention Society conference, Sydney 16-18 November 2014.

Ashari, A., and Hill, K.D. Establishing successful falls prevention research collaborations between Malaysia and Australia: Perspectives from a PhD candidate**.** Paper presented at 50th Australian Association of Gerontology Conference, Adelaide 24-26 November 2014.

Ashari, A., Hamid, T.A., and Hill, K.D. Falls risk assessment among community dwelling older adults Malaysian. Paper presented at 20th World Congress of International Association of Gerontology and Geriatrics (IAGG), Seoul, Korea, 21 -26 June 2013.

LIST OF AWARDS

Awarded of Scholarship from Federal Training Award, Ministry of Higher Education of Malaysia, 2010/2012.

Awarded Scholarship Federal Training Award, Ministry of Higher Education of Malaysia, 2012/2015.

Awarded Research University Grant, University Putra Malaysia.

Awarded Putra Research Grant Scheme (Putra Grant No: 9404500/2013), Universiti Putra Malaysia.

LIST OF ABBREVIATIONS

AAS	Adjusted Activity Score
ANOVA	Analysis of Variance
AUC	Area Under the Curve
AUD	Australian dollar
BMI	Body Mass Index
BOS	Base of Support
CI	Confidence Interval
cm	centimetres
COP	Centre of Posturography
DC	Directional Control
deg/sec	Degrees per second
ECAQ	Elderly Cognitive Assessment Questionnaire
EPE	End Point Excursion
F	F Distribution
FOF	Fear of Falling
FRT	Functional Reach Test
FTSST	Five Times Sit to Stand Test
FES-I	Fall Efficacy Scale International
GDS	Geriatric Depression Scale
HAP	Human Activity Profile
ICC	Intra class Correlation Coefficient
IQR	Interquartile Range
kg	kilograms
LOS	Limit of Stability
LL	Lower Limit
M	Mean
m	metres
MANOVA	Multivariate Analysis of Variance
MAS	Maximum Activity Score
mCTSIB	Modified Clinical Test of Sensory Interaction of Balance
Mdn	Median
min	minute
MVL	Movement Velocity
MXE	Maximum Excursion

MYR	Malaysian Ringgit
N	Number of participants in sample
OR	Odd Ratio
p	Probability
PCA	Principal Component Analysis
QOL	Quality of Life
RCT	Randomised Controlled Trial
RT	Reaction Time
SD	Standard Deviation
sec	Seconds
SQT	Step Quick Turn
ST	Step Test
STS	Sit to Stand
TUG	Timed Up and Go
TUG_{cog}	Timed Up and Go (cognitive dual task)
TUG_{m}	Timed Up and Go (manual dual task)
U3A	University of the Third Age
UL	Upper Limit
UPM	Universiti Putra Malaysia
WA	Walk Across
ŋ2	Eta Squared

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.0 Background

Falls and fall related injuries are recognised as common events that have become a major public healthcare concern, especially among older people. Falls problems and their consequences have also been known as one of the "giants" of geriatric medicine (Clements, 2008; Close, 2001). Because of the rapid growth in aged populations in many countries around the world, and the increase in falls with increasing age, it is now one of the most common and serious health problems in the older adult population. Studies have reported that approximately one third of older persons residing in the community fell at least once in a year (Blake et al., 1988; Cevizci et al., 2015; Dolinis et al., 1997; Kojima et al., 2008; Stevens et al., 2008; Tinetti et al., 1988). These falls resulted in serious injuries in 10-20% of cases, and 2-6% resulted in fracture or other serious injuries (World Health Organisation, [WHO], 2007) and these risks increase with age (Cumming, 1998; Faul et al., 2016).

Although there are many studies of falls risk factors and falls prevention interventions, the majority of these have been undertaken in Western countries. There have been a small number of studies that have reported falls incidence in Asian countries (Hua et al., 2007; Kwan et al., 2011a; Sohng et al., 2003). Previous Asian studies have indicated varying proportions of older people who fall, with between 10% and 31% of older people falling in a 12 month period (Hua et al., 2007). Differences in age, racial background, socio-demography, environment and population settings, life-style related to diet, activity, sunlight exposure, body dimensions, and culture between countries might all contribute to the differences of fall prevalence reported, and such factors may produce variations in the rate, circumstances and consequences of falls across different regions of the world (Bekibele & Gureje, 2010). Additionally, differences in sampling or recruitment, and methods of data ascertainment (retrospective vs prospective falls data), and possibly cultural differences in willingness to report specific health problems such as falls, may account for some of these differences. Research is needed to identify prevention strategies that will be effective in different cultural contexts (WHO, 2007).

Falls are caused by multiple factors and are influenced by interaction between intrinsic and extrinsic factors. The cause of falls in individuals also varies, thus a falls risk assessment can provide a comprehensive perspective of an individual's risk. Furthermore, a detailed assessment of fall risk factors and fall risk characteristics at individual levels can also be used as a basis for informing an appropriate fall prevention intervention. Balance impairment has been reported to be one of the strongest risk factors for falls (Graafmans et al., 1996; Muir et al., 2010).

Malaysia is an upper middle income country in south-east Asia with a total population of 29,864,600 (Department of Statistics Malaysia [DOSM], 2013) and has a growing ageing population. Globalisation and socio-economic development towards becoming a developed nation by year 2020 have brought a significant impact on the quality of life of the Malaysian older adult population (Tengku Aizan, 2012). Increasing longevity and declining fertility among Malaysia's population has accelerated the growth of the older population in Malaysia (Mafauzy, 2000). Malaysia will achieve aged nation status sometime between 2030 and 2035, when 15% or more of the total population are classified as old (> 60 years of age) according to projections by the Department of Statistics of Malaysia (Tengku Aizan, 2012; Yin Fah et al., 2010). In line with the National Policy for Elderly (NPE), Malaysia has goals of empowering individuals, families and communities through provision of elderly-friendly services and enabling environments to improve wellbeing in old age. Thus, early identification of the various aspects of local healthcare demands and baseline data to inform culturally appropriate intervention programs are seen as crucial.

In Malaysia, little is known about falls and injuries and contributory risk factors among older persons. Currently, there are no national Malaysian figures for falls prevalence among adults aged 50 years and above. There are two studies that have explored falls in community dwelling older people in Malaysia. One study investigated 516 older people (aged 60 years and above) who lived in the community, and reported a prevalence rate of falls of 27.3% (Rizawati & Mas Ayu, 2012). However the analyses in this study were limited to extrinsic risk factors (environmental factors causing falls). The other study by Sazlina et al. (2008) investigated the prevalence of falls among 151 community dwelling older people who attended a primary care clinic with varying health problems, and found the prevalence of falls was 47%, and that 57% of fallers reported recurrent falls in a 12 month period. Both of these studies reported that more than 50% of falls occurred at the home, and most frequent causes of falls recorded were slips on the slippery flooring, particularly in toilets and bathrooms.

Given the limited research undertaken in determining the magnitude of the problem of falls and associated contributory factors in the Malaysian context, this needs to be a research priority. Management strategies should be designed within the context of local needs and the Malaysian primary and public health care systems (Hamid, 2012).

Going by the definition used by Cowgill and Holmes in 1970 (Chen and Jones, 1989), Malaysia's society will be categorized as "mature" in 2020, when the percentage of the older population aged 65 years or over will reach the seven percent mark and the population median age will reach 30 years old (Hamid, 2012). Furthermore, by 2030, Malaysia is projected to become an aged nation, where 15% of the population will be aged 60 years and above. This is compared to just 7.8% of the population aged 60 and over in 2010 (Hamid, 2015).

The added years to life is reflected in the Malaysian national life expectancy statistics. Malaysian males born in 2015 can expect to live for 72.5 years while females born in the same year can expect to live to an average of 77.4 years (DOSM, 2015). An older man aged 60 years or over in 2010 can look forward to another 18.4 years of life, while it is 20.9 years for older women. The changing age structure and shifting demographic trends in fertility, mortality and life expectancy have resulted in a rapid ageing of the Malaysian population (Hamid, 2015). The shift in population age-sex structure has created a window of opportunity for the realization of the first demographic dividend which needs to be harnessed for future development. Policies and programs need to be designed at an early stage to take advantage of the demography window so that a second demographic dividend can be reaped (Bloom et al., 2003). Thus, in the scope of this thesis, because of Malaysia's relatively "young" demographics compared to many developed countries, the focus of the studies in this thesis is on adults aged 50 years and older.

In addition, balance assessment can provide useful information for planning suitable interventions. However, there are a large number of assessments available to assess different aspects of balance performance (Perell et al., 2001). To date in

Malaysia, no studies have been carried out investigating intrinsic risk factors for falls, and no studies have used a comprehensive suite including a combination of clinical and force platform balance assessment tests among community dwelling adults.

The importance of balance for independence and safety for older people, and the negative effect of age and health problems on balance ability has been well established (Nitz et al., 2003; Nolan et al., 2010; Ozalevli et al., 2011). Exercise has been a widely investigated intervention to improve balance and reduce falls risk (Howe et al., 2011; Sherrington et al., 2011). A Cochrane review reported that multi-component group exercise, typically including resistance and balance training, reduced the rate of falls by 22% and falls risk by 17% in adults aged 60 years and over (Gillespie et al., 2012). Howe and colleagues (2011) analysed results from 94 studies of exercise interventions aiming to improve balance, and found exercise interventions which involved dynamic standing balance, that are performed at least three times a week over a three months period could significantly improve balance and mobility among older adults. The Cochrane review also highlighted that there were inconsistent findings and lack of concrete evidence to support some of the balance outcomes investigated, and suggested that further robust randomised controlled trials should be implemented.

A number of balance intervention studies have focused on task specific exercises and every day activities such as getting in and out of a chair, or stepping up and down from one level to another (Nitz & Choy, 2004; Nnodim et al., 2006; Silsupadol et al., 2006; Steadman et al., 2003; Ullmann et al., 2010). However, the effectiveness of exercise programs to improve balance performance (and thereby reducing risk of future falls) has not been investigated among Malaysian adults aged 50 years and above. In addition, there has been little focus in falls prevention exercise interventions on improving one of the common specific physical tasks involved in falls circumstances – that being turning.

Thus, the studies in this thesis will provide culturally relevant information regarding falls prevalence and risk of falling among community dwelling adults aged 50 years and above in Malaysia, and these results form the basis for a data driven intervention study. In addition, these studies will add to current knowledge and understanding regarding improved falls risk assessment, which has potential to change current assessment practice by health professionals in Malaysia.

1.1 Thesis aims

To date in Malaysia there has been no study carried out investigating intrinsic falls risk factors, and none investigating in detail one of the important risk factors of balance impairment among community dwelling older adults (turning performance). Therefore, the studies reported in the first part of this thesis aimed to address the following research questions:

i. What are the prevalence rates and circumstances of falls among community dwelling Malaysian adults aged 50 years and above?
ii. Are there age and gender effects on fall risk factors among community dwelling Malaysian adults aged 50 years and above?
iii. What are the factors that contribute to falls among community dwelling Malaysian adults aged 50 years and above?
iv. What the most suitable fall risk assessment tools that could be useful to identify fall risk and balance performance among community dwelling Malaysian adults aged 50 years and above?

The first phase of these studies was conducted to obtain baseline information regarding the magnitude of the prevalence of falls, circumstances and relevant intrinsic risk factors for falls in community dwelling Malaysian adults aged 50 years and above, to inform future development of a culturally appropriate falls intervention program for application across Malaysia.

A falls prevention intervention program based on the data from identified local falls risk factors, was developed and implemented. Impaired turning performance was found to be one of the risk factors that differentiated fallers from non fallers. This informed the second phase of the studies in this thesis, which aimed to identify the effectiveness of an individualised home based exercise program to improve turning and balance performance among adults aged 50 years and older with mild balance and turning impairment. Hence, the second main study of this thesis aimed to address the research questions as below:

i. What is the effect of an individualised home based exercise program that includes exercise to improve turning performance on adults aged 50 years and above with mild turning impairment?

ii. Does participant adherence level with the home based exercise program play an important role in improving turning and balance performance?

1.2 Thesis outline

The review of the literature on the evidence for the definition, prevalence and risk factors for falls among older adult populations in Western and Asian regions are discussed in Chapter 2. There are a limited number of studies that have specifically investigated the prevalence and evaluate the risk of falls among adults aged 50 years and above in Asian countries. Several issues regarding variation in definition, data ascertainment, methodology and cultural differences between Asian and Western are identified. Previous research findings on the effectiveness of exercise interventions to improve balance and mobility performance and reduce risk of falls among community dwelling adults are critically discussed.

Chapter 3 describes details of the methodology used for the studies in this thesis, namely a cross-sectional study (Study 1) and a randomised controlled trial (Study 2). The detailed information regarding recruitment and inclusion criteria for the participants, fall ascertainment data, physical assessment, clinical and laboratory measures of balance, and the falls risk assessment using the Fall Risk for Older People in the Community (FROP-Com) are explained in detail. A protocol paper explaining the individualised exercise intervention on improving turning performance has been published, and is included in Appendix 1.

Chapter 4 reports the results of a prevalence and fall risk assessment study among Malaysian adults aged 50 years and above. The findings for this study (Study 1) were divided into four sections. Section 1 provides baseline information on prevalence and circumstances and consequences of falls. The effect of age and gender on balance and mobility performance measures and other falls risk factors are examined and discussed in section 2. Section 3 reports the associated risk factors for falls among the studied population. An abbreviated set of clinical measures for balance and mobility assessment based on a factor analysis of the detailed assessment outcomes is reported in Section 4.

Chapter 5 describes and evaluates a randomised controlled trial investigating the effectiveness of a home based exercise intervention to improve balance and mobility performance (including turning performance) among adults aged 50 years and above with mild turning impairment. A 16 week individualised home based exercise program was compared to usual care. Turning sway and turning time during the Step Quick Turn test (SQT) on the Neurocom™ force plate and Timed Up and Go were the primary outcome measures, and other clinical measures of balance and mobility as secondary outcomes are reported. The impact of adherence level on the primary outcomes are identified and discussed.

Chapter 6 discusses and summarises the overall findings from these studies and the associated clinical implications. The significance of the findings on prevalence, risk factors for falls and effectiveness of fall prevention interventions for Malaysian adults aged 50 years and above are discussed. Additionally, the strengths and limitations of the studies in this thesis are discussed. Future research directions for fall risk assessment and culturally appropriate fall prevention in the Malaysian context are proposed based on the current findings reported in this thesis.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter reviews the relevant literature specifically focused on three main broad areas of scope for the studies in this thesis, namely (1) the prevalence and consequences of falls, and falls risk factors and falls risk assessment, (2) turning impairment as a specific balance and mobility impairment and risk factor for falls, and (3) evidence of effective falls prevention interventions, with a focus on individualised home based exercise interventions aiming to improve balance and functional mobility among community dwelling older adults. Throughout this chapter, an emphasis is on comparing the research that have been carried out in Asian populations (the focus of the studies in this thesis) with research from other parts of the world.

2.1 Definition of fall

In general, falls are defined as an episode, which results in a person coming to rest inadvertently on the ground, floor, or a lower level with injury or non-injury (WHO, 2007). However, a number of different falls definitions have been used in previous studies. The variation and diversity in defining falls causes difficulty in making comparisons between studies. A previous study reported that falls definitions were found to be different in different populations (Zecevic et al., 2006), and even a small alteration in definition was found to have an impact on the outcome of the study (Jitapunkul et al., 1998b; Scheffer et al., 2008). Hence, in epidemiological and intervention studies of falls, it is crucial to consider judiciously the definition used for a fall. The different interpretation of what a fall is among older people could reduce the validity and reliability of the study (Masud & Morris, 2001; Zecevic et al., 2006). Examples of some of the various definitions of falls used in the falls prevention literature are reported in as shown in Table 2.1.

Table 2.1: List of selected falls definitions reported in the research literature

Author	Selected Fall Definitions
Gibson et al. (1987)	"A fall is an event which results in a person coming to rest inadvertently on the ground or other lower level and other than as a consequence of the following: Sustaining a violent blow, loss of consciousness, sudden onset of paralysis as in a stroke, an epileptic seizure" (p. 4).
Chu et al. (1999)	"...a fall was defined as an event resulting in a person coming to rest unintentionally on the ground or other lower level, not due to any intentional movement or extrinsic force (e.g., being knocked down by a trolley)" (p. 38).
Buchner et al. (1993)	"Unintentionally coming to rest on ground, floor, or other lower level; excludes coming to rest against furniture, wall, or other structure" (p. 301).
Means et al. (1996)	"… any involuntarily change from a position of bipedal support (standing, walking, bending, reaching, etc.) to a position of no longer being supported by both feet, accompanied, by (partial or full) contact with the ground or floor" (p. 1032).
Canadian Institute for Health Information (2002)	"… an unintentional change in position where the elder ends up on the floor or ground".
Carter et al. (2002)	"… inadvertently coming to rest on the ground or other lower level with or without loss of consciousness and other than as the consequence of sudden onset of paralysis, epileptic seizure, excess alcohol intake or overwhelming external force" (p. 999).
Tideiksaar (2002)	"… any event in which a person inadvertently or intentionally comes to rest on the ground or another lower level such as a chair, toilet or bed" (p. 15).
Organisation (2007)	A fall is defined as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level.
Close et al. (1999).	Inadvertently coming to rest on the ground or other lower level with or without loss of consciousness and other than as a consequence of sudden onset of paralysis, epileptic seizure, excess alcohol intake, or overwhelming external force.
NICE (2004)	An event whereby an individual comes to rest on the ground or another lower level with or without loss of consciousness.
Tinetti et al. (1988)	"an event which results in a person coming to rest unintentionally on the ground or lower level, not as a result of a major intrinsic event (such as a stroke) or overwhelming hazard."

Note. Modified from "Defining a fall and reasons for falling: comparisons among the views of seniors, health care providers, and the research literature", by Zecevic, A. A., Salmoni, A. W., Speechley, M., & Vandervoort, A. A. (2006). Defining a fall and reasons for falling: comparisons among the views of seniors, health care providers, and the research literature. *Gerontologist, 46*(3), 367-376

For the purpose of this thesis, a fall is defined as "….an event which results in a person coming to rest inadvertently on the ground or other lower level, other than as a consequence of sustaining a violent blow, loss of consciousness, or sudden onset of paralysis, as in a stroke or an epileptic seizure" (Kellogg International Work Group, 1987, p. 4). .This definition consists of two main elements which have been recognised to distinguish falls and to classify the different type of falls. It was developed to provide consistency in defining falls and allow researchers to make comparison between studies. In addition, Lord et al. (2007) suggested that the Kellogg's definition was appropriate for studies which aimed to identify the prevalence of falls related to the sensorimotor impairment and balance. Recommendations for falls prevention research include that ideally falls data are collected over a standard period of 12 months (Lamb et al., 2005).

2.2 Epidemiology of falls

Falls are common events among older people and have been known as one of the "giants" of geriatric medicine (Organisation, 2007). Over the past two decades, with the rapid growth of the older population worldwide, falls and fall related injuries have become more prominent as a major health problem among ageing populations, and constitute a significant public health concern in modern society (Masud & Morris, 2001; Peel, 2011; Sattin, 1992). It is well established that approximately one third of community dwelling older people fall each year (Dolinis et al., 1997; Lord et al., 1994; Tinetti et al., 1988). Falls are the second leading cause of injuries worldwide, with an estimated 424,000 people dying from falls each year (WHO, 2012). In Australia, falls are now the leading cause of injury related hospitalisation among older people age 65 years and above. A recent report indicated approximately 96,000 cases of falls injury resulted in hospitalisation (Tovell et al., 2014). Whilst more than 50% of the cases involved older people (aged 60 years and older), 70% of the cases occur in developing countries (WHO, 2012). Recently, the United States Centre for Disease Control and Prevention (CDC, 2012) reported that there were more than two million non-fatal falls treated in emergency departments. Furthermore, approximately 1.6 to 3.0 per 10,000 older people aged 60 years and above in Australia, Canada and England were hospitalised due to falls (WHO, 2007). Falls can result in functional disability and dependency, immobility, reduced quality of life and increased psychological and psychosocial problems (Rubenstein, 2006; Stewart et al., 2015).
Due to the devastating consequences of falls, this phenomenon has raised considerable attention in an attempt to prevent falls in the last two decades. A

considerable amount of literature has been published on falls prevalence and fall risk factors. However, most of the published data and findings have been established in western countries. Comparatively little information has been published on falls prevalence and risk factors for falls in older populations in developing countries such as a number of countries in the Asian region (Jagnoor et al., 2013).

Epidemiology studies on falls and fall risk factors have reported that there are variation in fall rates between countries. Some factors that might contribute to these different rates of falling, circumstances and consequences of falls across different regions of the world may include sample differences in age, racial background, genetic, socio-demography, environment and population settings, life-style (diet, activity, sunlight exposure), body dimensions, and culture (Aoyagi et al., 1998; Bekibele & Gureje, 2010; Han et al., 2014; Hua et al., 2007; Jagnoor et al., 2013).

In addition, differences in study design (retrospective vs prospective) of fall ascertainment could lead to variations in reported fall rates (Hauer et al., 2006; Masud & Morris, 2001; Zecevic et al., 2006). These variations in methodology result in difficulties for researchers to make an evaluation and comparison between countries (Masud & Morris, 2001). Further evidence of the difference in data collected through prospective compared to retrospective data collection methods was shown in a prospective study conducted among 96 healthy community dwelling older women aged 70 years above by Hill et al. (1999). This study found that 14.8% of follow up falls within a 12 month period (data collected prospectively through use of falls diaries) were not reported when participants were asked at the end of the 12 month period to recall falls in the preceding 12 months. In a similar study, Hannan and colleagues found that three months recall of falls resulted in underreporting of falls by as much as 25% compared to daily calendar (Hannan et al., 2010).

2.2.1 Magnitude of the falls problem among community dwelling older people

In the United States, falls are a major health problem, where approximately 30% of community dwelling adults aged 65 years and above fall each year, with this increasing to over 50% among those aged over 75 years old (Stevens et al., 2006; Tinetti et al., 1988). Falls and falls related injuries are also a leading cause of disability and trauma related death among people aged 65 years and above (Hester & Davis, 2013; Tinetti et al., 1988). Furthermore, the rate of fatal falls from year 2000 to 2006 increased by 42% for people aged 65 years (Hu & Baker, 2010).

In Australia, falls are also common, and have become a significant threat to the health, independence and wellbeing of older people. A National report indicated 20 percent of home falls among Australian older people resulted in hospitalisation and the injury rates increase significantly with age (AIHW, 2013). In 2006, about four out of 1000 falls injury cases occurred among those aged 75 years and above, which was double that of those aged 65-74 years (AIHW, 2013). In addition, based on the New South Wales Fall Prevention Baseline Survey among 5681 community dwelling people aged 65 years and above, 25.6% of the sample had falls in the previous 12 months, and about 39% of fallers had more than one fall (Milat et al., 2011).

2.2.2 Falls scenario in Asian countries

Recently, there has been growing interest in many Asian countries in falls studies. Epidemiology studies in Asian populations have generally reported lower rates of falls compared to western populations. Hua et al. (2007) published a report of falls and prevalence in the Western Asia Pacific region, and indicated that the proportion of fallers among older people ranged from 10.5% to 31% (Hua et al., 2007).

When looking at individual countries in the Asian region such as in China and Japan, rates of falls between 6%-31% and 15%-33% have been reported respectively (Aoyagi et al., 1998; Chu et al., 2005; Hua et al., 2007; Kojima et al., 2008), which seem to be lower compared to western countries (Campbell et al., 1989; Milat et al., 2011; Tinetti et al., 1988). A possible explanation for the lower rate of falls in Asian populations could be related to underreporting of falls, since most of the population based studies of falls data in Asian countries were obtained retrospectively. With retrospective falls data collection (e.g.; asking participants if they have fallen in the past 12 months) there is increased possibility of forgetting to recall, especially minor falls that do not cause an injury, which could contribute to the lower rate of fall (Cummings et al., 1988).

Studies documenting falls incidence in countries in Asian region are summarised in Table 2.2. These include studies in Taiwan (Chang et al., 2010), Hong Kong (Chu et al., 2006), Korea (Shin et al., 2009a; Sohng et al., 2004), India (Krishnaswamy & Usha, 2006), and Singapore (Chan et al., 1997). These small number of studies have reported varying rates of fall, from 10% to 37% among older people in a 12 months period (generally > 60 years of age).

Table 2.2: Studies of fall prevalence among older Asian population

Country	Authors	Study Design	Study population	Falls ascertainment	Fall prevalence rate (%)
Singapore	Chan et al. (1997)	Retrospective	401 people, aged 60 years and above	fall in previous 12 months	17.2
Thailand	Jitapunkul et al. (1998b)	Retrospective	4,480 people aged 60 years and above, Multistage random sampling	fall in previous 6 months	18.7
	Assantachai et al. (2003)	Retrospective	1043 urban community dwelling aged 60 years and above	fall in previous 6 months	19.8
	Sophonratanapokin et al. (2012)	Retrospective	26,689 community dwelling aged 60 years and above, National survey (2007)	fall in previous 6 months	10.4
Hong Kong	Chu et al. (2005)	One year Prospective	1517 population-based sample of community dwelling adults aged 65 years or over	fall in 12 months follow-up	19.3
Taiwan	Chang et al. (2010)	Cross sectional	1361 community-dwelling elderly who had been enrolled in the Shihpai Eye Study	fall in previous 12 months	16.3
Korea	Shin et al. (2009a)	Retrospective	335 participants community dwelling sub sample Ansan Geriatric (AGE) study	fall in previous 12 months	15.0
	Choi et al., (2014)	Retrospective	56,624 people, aged 65 years and above Korean Community Health Survey (KCHS) 2011	fall in previous 12 months	16.9 (males) 24.3 (females)
Japan	Aoyagi et al., (1998)	Retrospective	1534 participants aged 65 years and above, community dwelling	fall in previous 12 months	15.2
India	Krishnaswamy and Usha (2006)	Survey	10,200 people from urban and rural areas	fall in the previous 6 months	14.0

In summary, while reported rates of falls in Asian countries have tended to be lower than in western countries, it remains unclear to what extent this is a real difference, or related to different methods of data collection, or population / cultural differences. Furthermore, falls were often seen as an unavoidable event and appeared to be poorly understood by older adults in less developed countries (Jagnoor et al., 2014). There is a need for more detailed exploration of falls and falls risk factors in Asian countries to inform an effective and culturally appropriate falls prevention program that suits the targeted population (WHO, 2007).

Kwan et al. (2011a) conducted a review that revealed there was a consistently lower incidence of self-reported falls among Chinese older people as compared in Caucasian older people, even though the types and prevalence of risk factors were similar from those found in studies of Caucasian older people. This review suggested that a greater understanding of the health, behavioural and lifestyle factors that influence fall rates in Chinese populations is required for elucidating fall prevention strategies in Chinese and non-Chinese older people. In addition, the variations in reporting fall prevalence rate was contributed by the wide range of characteristics associated with community-dwelling older adults over the age of 65 who report falling in the previous 12 months.

Furthermore, the rapid growth of the older population in the Asian region magnifies the impact of the increasing rate of fall in this region. For instance, India became the country with the second highest number of older people in its older population. It consisted of 76.6 million people aged 60 years and above, which accounted for about eight percent of the total population in India (Dsouza et al., 2014). In this context, India has a “young” aging population, but the percentage of its population and therefore the number of people in this older age group will grow rapidly in coming years. Consequently, one fifth of falls reported by the WHO (2007) were estimated to be from India.

In terms of falls related injuries, the hip and thigh were the most commonly affected areas, and more women sustain hip fracture due to the higher prevalence of osteoporosis. In another related study on identifying risk of falls among Indian older people, (Krishnaswamy & Usha, 2006) reported that muscle weakness, history of falls, polypharmacy, use of assistive devices, arthritis, depression, age older than 80 years, gait and balance impairment and reduced functional daily activities and cognitive function contributed to risk of falls among the Indian population.

In the 2011 Korean Community Health Survey, out of 43,367 participants in a representative sample of community dwelling Koreans aged 65 years and above, the prevalence of falls among males and females was reported as 17% and 24% respectively (Eun et al., 2015). In Japan, it has been estimated that approximately 20 percent of people aged 60 years and above fell each year (Hua et al., 2007). The incidence of falls was higher in women compared to men and increased with age (Aoyagi et al., 1998). Furthermore, Aoyagi et al. (1998) has conducted a population based study among 1534 community dwelling people aged 65 years and above and found 10% to 20% fall each year, and 10% of fallers sustain fractures as a result of falls (Aoyagi et al., 1998).

In Thailand, based on the interview conducted in the National Survey among 4,480 Thai elders aged 60 and over, Jitapunkul et al. (1998b) found 19% of participants reported falls in the previous six months. Women (21%) were more likely to fall compared to men (14%). The study revealed that environmental and intrinsic health factors which affected balance and gait were the main factors associated with falls among Thai older people, and nutritional status was identified as a contributing fall risk factor for Thai older women (Jitapunkul et al., 1998b). Additionally, (Assantachai et al., 2003) reported similar findings from a cross-sectional study among 1,043 urban community dwelling adults aged 60 years and older in Thailand. Results indicated that the prevalence of falls was about 20% and the Activities of Daily Living (ADL) limitations, nutritional status, kyphosis, hypertension, and cognitive impairment were found to be associated with falls among community dwelling older women in urban areas in Thailand (Assantachai et al., 2003).

In contrast, there is very limited data on falls prevalence in Malaysia, and data that is available is from hospital outpatients. A previous study reported the prevalence of falls among 151 outpatients aged 60 years and above was 47%, and more than half of the fallers had more than more than one fall. It was noted that this fall prevalence rate was considerably higher than other studies (Sazlina et al., 2008). This study also reported that home hazards were commonly associated with falls. None of the significant underlying comorbidities and other intrinsic risk factors such as polypharmacy and awareness could differentiate between fallers and non fallers. The higher rate might be due to the sample population, where most patients had medical conditions which increased their propensity for falling. Moreover the sampling for this study was not representative of the whole population.

In summary based on the current literature on falls prevalence and fall risk factors among community dwelling Asians aged 60 years and above, falls rates from most studies ranged from 10% up to 22%, except for one Japanese study, and the single study of Malaysian older people. The prevalence rate of falls was seen to be lower compared to western populations. However, due to the rapid growth of the ageing population in the Asian region, and the increasing rate of fall related injuries among older persons, falls are becoming an increasingly significant problem to Asian older people and their governments. In countries such as Malaysia, where there is very limited falls data available, further studies are required to identify the prevalence, circumstances, and risk factors associated with falls, so that culturally appropriate interventions to address this major health problem for older people can be developed and evaluated.

2.3 Consequences of falls

Fall related injuries are a major problem among community dwelling older adults. The consequences of falls could cause a diversity of outcomes such as physical injury, psychological impacts, psychosocial effect, reduced quality of life or even death. Falls are the leading cause of non-fatal and fatal injuries and death among older people (WHO, 2007). Injuries associated with falls increase with age. Approximately 40 to 60% of falls lead to injuries, with 30-50% being minor injuries, 5-6% major injuries excluding fracture and 5% are fractures (Masud & Morris, 2001). The most common self-reported physical injuries are cuts, bruises and sprains, whilst the most common injuries that require medical treatment and hospitalisation comprise hip fracture, pelvic fracture, leg and wrist fractures, neck and trunk injuries, and intracranial bleeding. The World Health Organisation has reported that the injuries related to falls among older people are the leading cause of hospitalization, accounting for 14% of emergency admissions and four percent of hospital admissions (WHO, 2007). The rate of hospitalisation due to falls increased exponentially with advancing age for both genders (Hartholt et al., 2011).

2.3.1 Mortality

Fatal falls are a major public health problem, and are likely to continue to increase as the older population grows with population ageing. It is estimated that 424,000 people worldwide die from falls, and 80% of falls occur in low and middle income countries, with two thirds of these deaths occurring in the Western Pacific and South East Asian Region (Jagnoor et al., 2014). According to the United States National Centers for Injury Prevention and Control (2010), approximately 22,900 older people died from unintentional injuries, and the death rate of fatal falls was 41% higher in men compared to women. In addition, it was also reported that there were variations in fatal falls rates between ethnic groups, where fatal falls were higher among non-Hispanics (Stevens et al., 2006). Older whites were reported as being about three times more likely to have a fatal fall compared to older black people, and the risk of dying from falls increased as people aged.

People aged 65 years and older are 10-150 times higher risk to die from a fall than those in younger age groups (WHO, 2012). Similar findings based on a recent review on epidemiology of falls in India has reported that falls became the leading cause of accidental death among older adults aged 75 years and the second highest cause of accidental death among those aged 65-74 years old (Dsouza et al., 2014). Men aged 65-74 years had higher fatal falls rates compared to women from the similar age group, while after the age of 75 years women were more likely to die due to falls.

Furthermore, in a study conducted in the United States of America among people aged 75 years and older, 66% of falls involved people aged 75 or older; and this age group had a mortality rate eight times higher than for individuals aged from 65 -74 years (Hu & Baker, 2012). The highest proportion of fatal falls were reported after the age of 85. Of those hospitalised due to falls, approximately 50% died within a year (Rubenstein, 2006). Whilst in the hospital setting, it was reported that 10% of these patients died before discharge, and 1,800 fatal falls occurred by those discharged to nursing homes(Rubenstein et al., 1996).

2.3.2 Morbidity

A WHO report found that approximately 37.3 million falls which are severe enough to require medical attention occur each year. Such falls are responsible for over 17 million DALYs (disability-adjusted life years) lost. The largest morbidity occurs in people aged 65 years or older, young adults aged 15–29 years and children aged 15 years or younger (Organisation, 2007).

In Australia, it was reported that 22-60% of older people suffer injuries from falls, 10-15% suffer serious injuries, 2-6% suffer fractures and 0.2-1.5% suffer hip fractures

(Tovell & Harrison, 2013). The most commonly self-reported injuries include superficial cuts and abrasions, bruises and sprains. Most common injuries that require hospitalisation comprise femoral neck fractures, other fractures of the leg, fractures of radius, ulna and other bones in the arm and fractures of the neck and trunk (Tovell & Harrison, 2013).

In terms of morbidity, one of the most serious of these fall-related injuries are hip fractures. About 90% of hip fractures cases reported resulted from fall related injuries (Grisso et al., 1991). In 2010 in the United States of America there were 258,000 cases of hip fractures among people aged 65 years and above admitted to hospital (Centers for Disease Control & Prevention, 2008). The incidence of hip fractures was parallel to the world projection of hip fracture from an early study that projected the number of hip fractures occurring in the world each year would rise from 1.66 million in 1990 to 6.26 million by 2050 (Parkkari et al., 1999). However, between 1990 and 2010, the trend for hip fractures actually declined for both genders in some countries, but the factors contributing to this are unknown (Stevens & Rudd, 2013). This trend for reducing hip fractures has also been seen in Australia, although over the same period, total hospitalisations due to all falls related injuries actually increased (Tovell et al., 2014). Older people recover slowly from hip fractures and are vulnerable to post-operative and bed rest complications. In around 25% of cases, hip fractures result in death and of those who survive, around one third of them never regain complete mobility (Lord et al., 2007).

Another consequence of falling is the long lie, where a faller remains on the ground for more than an hour after a fall. The long lie is often seen as a sign of weakness, illness and social isolation, and is commonly correlated with high mortality rates among older people. In addition, those individuals who fall and suffer a disability, particularly older people, are at a major risk for subsequent long-term care and institutionalisation (Lord et al., 2007).

In Australia in the year 2009 to 2010, the number of hospitalised injury cases due to falls in people aged 65 and over was 83,768, which was seven percent higher compare to the previous year 2008–09 (Tovell & Harrison, 2013). This figure accounted for three percent of all hospital separations for the population aged 65 and older. It was noted that approximately one third of fall injury cases affected the hip and thigh area, with the majority of these injuries requiring hospitalisation being hip fractures. Overall, one in ten days spent in hospital by a person aged 65 years and above were attributed to injurious falls, and it was estimated that the average time spent in hospital per injury related fall was 15.5 days. In terms of gender, women sustained a greater number of injurious falls requiring hospitalisation than men, and the mean age for hospitalized injurious fallers was 81.9 years (8.1SD).

In an American study, Stevens and Sogolow (2005) analysed 22,560 cases from a national representative sample of Emergency Department (ED) visits from January 2001 to December 2001 and estimated that 1.64 million older adults were treated in EDs due to unintentional fall injuries. Of these, approximately 1.16 million or 70.5% were women. Fractures, contusions/abrasions and lacerations accounted for more than three quarters of all injuries. Rates for injury diagnoses were generally higher among women, most notably for fractures, which were two times higher than for men. For all parts of the body, women's injury rates exceeded those of men. Rate ratios were greatest for injuries of the leg/foot (2.3), arm/hand (2.0), and lower trunk (2.0). The hospitalization rate for women was 1.8 times higher than for men.

Furthermore, Hartholt et al. (2011) noted that fall related hospitalisations in people aged 65 years and above in the United States has increased significantly within their eight years study, from year 2001 to 2008. This study aimed to determine secular trends in unintentional fall related hospitalisation based on the National Electronic Injury Surveillance System All Injury Program. Findings have estimated that within the eight year study, the incidence of fall related hospitalisation in older adults increased 50% from 373,128 to 559,355. The age adjusted incidence rate per 10,000 of population increased from 1,046 to 1,368, with the average age-adjusted incidence rate increasing 3.3% annually. Women were reported to have higher incidence rate as compared to men. This finding suggested that the underlying causes for the rising trend of fall related hospitalisation should be a priority and better future health outcomes for older adults should be targeted (Hartholt et al., 2011).

In summary, fall related hospitalisation rates have continued to increase over recent years in a number of countries, despite greater awareness and research into the problem of falls over this period.

2.3.3 Psychological and psychosocial implications

As well as the deaths and fall related injuries described above, falls can also cause psychological and psychosocial consequences to the faller (Kong et al., 2002; Leung et al., 2010; Tedeiksaar, 2010). Both non-injurious and injurious falls could result in the development of post fall syndrome that can lead to activity restriction, disability and reduced mobility that often results in diminished independence (Aoyagi et al., 1998; Fletcher et al., 2010; Howland et al., 1993; Scheffer et al., 2008; Tinetti et al., 1988; Vellas et al., 1997). Other associated consequences include reduced quality of life and increased likelihood of being institutionalised (Boyd & Stevens, 2009; Rubenstein, 2006; Tinetti, 2003). The psychological distress in older people can be even greater in those who suffer serious injuries (Berg et al., 1997; Vellas et al., 1997). The sense of being fragile, dependent, loss of confidence, anxiety, and vulnerability could become a sign of decline in health and reduced quality of life (Kong et al., 2002; Li et al., 2003; Yardley & Smith, 2002).

One of the common psychological consequences related to falls is fear of falling. Fear of falling is not only present among fallers but also for those who have never fallen. A review on prevalence of fear of falling reported the prevalence of fear of falling among community dwelling older adults is varied, from 3% to 85%, due to the inconsistent measurement tool used in the studies (Scheffer et al., 2008), and was most prevalent of among women as compared to men (Howland et al., 1993; Scheffer et al., 2008). Moreover, an excessive fear of falling can cause older people to reduce their social engagement and to avoid activities (Murtagh et al., 2015), and is associated with depression and anxiety (Deshpande et al., 2008; Painter et al., 2012), loss of independence, poor health status (Chang et al., 2010), and reduced quality of life (Bertera & Bertera, 2008; Lachman et al., 1998; Park et al., 2014; Tennstedt et al., 1998).

Similar findings were reported from Asian studies. The prevalence of fear of falling among community dwelling older people ranged from 30 to 76% (Aoyagi et al., 1998; Apikomonkon, 2003; Chang et al., 2016; Eun et al., 2015; Kim et al., 2014; Mane et al., 2014; Oh et al., 2015) and was considered a common psychological consequence resulting from falls. A cross-sectional study in Japan found 92 percent of fallers reported fear of future falls, and 30 percent had limited or reduced their outdoors activities. A number of studies have been conducted to identify the correlate factors for fear of falling among Asian older populations. These studies have indicated that older age, history of falls, female gender, poor health, low socioeconomic, medical conditions, balance impairment, and depression were significantly associated with the prevalence of fear of falling (Aoyagi et al., 1998; Chang et al., 2016; Chang et al., 2010; Choi et al., 2015; Kim & So, 2013; Mane et al., 2014; Oh et al., 2015; Park et al., 2014).

2.3.4 Economic consequences

Since falls in older people are common and can cause numerous injuries, disability, emergency care and medical treatment and even death, therefore falls are associated with high health care costs. Falls are costly and have now become recognized as a relevant economic burden to the individual, healthcare system and society (Alamgir et al., 2015; Heinrich et al., 2010).

According to the Australian Institute of Health and Welfare's Injury report 2010-2011, it is projected that the number of hospital bed days per year required due to falls will nearly double from 240,000 in 2010 to 450,000 in 2051 (Tovell & Harrison, 2013). Increasing demand and number of beds in nursing care was projected to increase up to 1.8 million in years 2051. The report also indicated that four percent of all hospital admissions in people aged 65 years and above were due to falls. The incidence of hospital admissions increases exponentially with age, and relative to those aged 40 years and above, the admission rate due to falls increases consistently by 4.5% per year for men (doubling every 15.7 years) and by 7.9% per year for women (doubling every 9.1 years). In those aged 85 years and over, the levels have climbed to four percent per annum in men and seven percent per annum in women. Therefore, this projected demand for increased hospital and residential care beds to manage the increasing numbers of older Australians experiencing injurious falls, will require higher financial allocation from individuals and government (Tovell & Harrison, 2013).

An American study by Stevens et al. (2006), reported there were 10,300 fatal falls and 2.6 million fall related injuries recorded in the year 2000. The total cost for fatal falls and medical treatments for fall related injuries were about 0.2 billion dollars and $19 billion respectively. For the nonfatal cost, 63% ($12 billion) was attributable to hospitalization costs, 21% ($4 billion) were for emergency department visits, and 16% ($3 billion) were for treatment in outpatient settings. The study also indicated that the medical expense for women was two to three times higher than for men for all medical treatment settings. In addition, a study by Hartholt et al. (2011) indicated that €474.4 million were attributable to falls related injuries, and found that both admitted and non-admitted fallers had a reduced quality of life for up to nine months after injury.

In summary, falls often have a devastating impact for the older adult, due to the high proportion of injuries as well as the psychological impacts such as loss of confidence, all potentially affecting quality of life. Moreover, these consequences provide a negative impact to the carers, family members, society and also increase the healthcare costs, which results in economic burden to the country.

2.4 Falls risk factors

Falls in older people are often precipitated and triggered by complex interactions between demographic, physical, medical, psychological and behavioural risk factors (Ambrose et al., 2013; Campbell et al., 1989; Deandrea et al., 2010). As the number of risk factors increases, the risk of falling and being injured increases. Furthermore, most falls are due to more than single factor (Ambrose et al., 2013; Delbaere et al., 2013; Lord et al., 2007). A previous epidemiological review on falls indicated that over 400 risk factors has been identified and contribute to falls (Masud & Morris, 2001). These risk factors have been divided into two main groups: intrinsic and extrinsic factors. Intrinsic risk factors are those related to the individual's specific risk, which includes demographic and biological factors, while extrinsic risk factors encompass environmental and behavioural factors (American Geriatric Society [AGS], 2011). Therefore, it is recommended that a fall event should be seen as a non-specific sign or symptom of underlying problems that were caused by either intrinsic or extrinsic risk factors, or a combination of these (Tedeiksaar, 2010).

Fall risk factors can also be classified as modifiable or non-modifiable risk factors. Modifiable factors refer to those risk factors that can be improved or ameliorated with intervention or treatment, while non-modifiable risk factors are not able to be influenced by intervention, for example advanced age, history of falls, gender, race and ethnicity (Ambrose et al., 2013; Deandrea et al., 2010; Finlayson & Peterson, 2010; Peel, 2011). Examples of modifiable risk factors include low level of physical activity, impaired physical and psychological status (e.g.; depression), acute illness, mobility, medication and polypharmacy (Finlayson & Peterson, 2010).

For the purpose of this thesis, the discussion and the critical review focused on falls risk factors identified in the published meta-analysis by Deandrea et al. (2010) which mainly focused on modifiable and non-modifiable fall risk factors associated with falls among community dwelling older adults. This review provides comprehensive evidence of fall risk factors from 74 prospective studies carried out among community dwelling adults aged 65 years and above. Identified risk factors were categorised based on the analytical classification proposed by Lord et al. (2007) into eight categories, namely socio-demography, balance and mobility, sensory, neuromuscular, psychological, medical conditions, medications and environmental.

Deandrea et al. (2010) reported 31 falls risk factors that were associated with falls among community dwelling older adults. A number of well-established risk factors documented for falls are advanced age, female gender, gait and balance deficits, muscle weakness, slow walking speed, dizziness and vertigo, mobility limitations and the use of assistive devices, living alone, pain, functional limitations with dependence in activities of daily living (ADL), assisted toileting and cognitive impairment. Medical conditions such as cardiovascular disease and heart failure, diabetes, arthritis, dementia, depression and incontinence are also established risk factors. Overall, the meta-analysis indicated that the estimated odd ratios were generally higher among recurrent fallers compared to single fallers (Deandrea et al., 2010).

This meta-analysis contributed a comprehensive analytical categorisation of fall risk factors among older people. Furthermore, it also provided more robust evidence of fall risk factors than some other reviews, as it only included data from prospective studies, rather than including retrospective studies, which suffer from lower accuracy of the falls outcome due to limitations of recall of falls over prolonged periods such as 12 months. However, there were also some limitations associated with the Deandrea et al. (2010) review, as most of the fall risk factors were extracted from Western and Caucasian studies. Recently, Han et al. (2014) in his review indicated that differences of ethnicity, region, cultural and environment could contribute to the discrepancy in falls risk factors between different populations. This is an emerging and important area of falls prevention to ensure that interventions are targeting culturally relevant risk factors.

Therefore, in an attempt to identify any differences and to have better understanding on fall risk factors among older people in Asia, a more recent systematic review on falls risk factors from 21 studies among Chinese populations in six Asian countries has been published by Kwan et al. (2011a). In addition a recent population based study on fall risk factors among Korean older people published by Eun et al. (2015), adds to this emerging evidence. These papers were reviewed to identify any differences in risk factors between older Asian populations and the results primarily from western populations (except one study conducted in Hong Kong) published by

Deandrea et al. (2010). All significant falls risk factors from these studies are summarised in Table 2.3.

Kwan et al. (2011a) identified 132 falls risk factors associated with falls among community dwelling Chinese older people aged 60 years and above. Of these, 18 risk factors were identified that were found to be significant at least in four studies and 10 were significant in the meta- analysis. History of fall, female gender, decreased activities in daily living, use of multiple medications, and older age were found to be the strongest risk factors reported among Chinese older populations.

Both reviews were generally consistent with findings reported in the most recent population based study among 56,624 Korean adults aged 65 years and above (Eun et al., 2015). The number of falls in the last 12 months was measured retrospectively. This study reported that female gender and age were strongly associated with higher risk of falls. In addition, older adults who were diagnosed with medical conditions such as diabetes mellitus, stroke, osteoarthritis, osteoporosis, urinary incontinence, or cataracts had higher risk of falls. Moreover, poor self-rated health and depression were also associated with increased risk of falls. In Asian studies, being married or having a partner was found to be associated with decreased risk of falls among Chinese and Korean populations, although this is was not identified in the Deandrea and colleagues' review (2010).

Although in the present reviews, many of the risk factors for falls reported among Asian studies are not dissimilar, there are some distinctions between these reviews that appear to be significant in western populations that are either non-significant or have not been investigated in the Asian studies, or vice versa. For instance, cognitive impairment was reported to be a significant risk factor for Western populations, but was not significant for the Chinese population. This variation may result from a limitation of Kwan's review which included both retrospective and prospective study designs (only four prospective studies and nine using random sampling) as compared to the Deandrea's review that included only prospective studies.

Furthermore, it is important to note that there is considerable diversity of socioeconomic, culture, ethnicity and environment between some of the countries and within the countries in Asia that might lead to the variation of risk factors.

Table 2.3: Summary of fall risk factors between two systematic reviews by Deandrea et al. (2010) and (Kwan et al., 2011a) and a large population based study (Eun et al., 2015).

	Risk factors	Deandrea et al. (2010) OR (95% CI)	Kwan et al. (2011b) OR (95% CI)	Eun et al. (2015) OR (95% CI)
1	**Sociodemographic**			
	Age	1.12 (1.07-1.17)*	1.1-2.2	1.10 (1.04-1.17)
	Sex (female)	1.30 (1.18-1.42)*	1.5-2.9	1.17 (1.08-1.27)
	Living alone	1.33 (1.21-1.45)	2.1 (1.2-3.1)	NS
	History of fall	2.77 (2.37-3.25)	1.7-10.2	NS
	Physical Activity	1.20 (1.04-1.38)	NS	0.95 (0.89-1.02)
	Physical Disability	1.56 (1.22-1.99)	NS	NS
	Instrumental Disability	1.46 (1.2-1.77)	1.6-3.9	NS
	Body Mass Index	1.17 (0.93-1.46)	NS	1.01 (1.00-1.02)
	Education level	1.01 (0.88-1.16)	NS	1.05 (0.98-1.13)
	Walking aid	2.18 (1.79-2.65)	1.6-2.8	NS
	Marital status	NS	1.2-2.8	1.13 (1.05-1.21)
	Location (rural vs urban)	NS	NS	1.13 (1.03-1.17)
2	**Psychological**			
	Cognitive impairment	1.36 (1.12-1.65)	NS	NS
	Self-perceived health	1.50 (1.15-1.96)	1.0-2.9	1.16-1.38
	Fear of falling	1.55 (1.14-2.09)*	1.9-3.1	NS
	Depression	1.63 (1.36-1.94)	1.4-4.6	1.47 (1.27 -1.70)
3	**Balance and Mobility**			
	Dizziness and vertigo	1.80 (1.39-2.33)	NS	NS
	Gait problem	2.06 (1.82-2.33)	1.4-2.6	NS

Note: NS = not specified OR = odd ratio, CI = confidence interval, * = indicates significant risk factors

Table 2.3: (continued). Summary of fall risk factors between two systematic reviews by Deandrea et al. (2010) and (Kwan et al., 2011a) and a large population based study (Eun et al., 2015)

	Risk factors	Deandrea et al. (2010) OR (95% CI)	(Kwan et al., 2011a) OR (95% CI)	Eun et al. (2015) OR (95% CI)
4	**Medication**			
	Number of medications	1.06 (1.04-1.08)*	1.1-2.6	NS
	Sedatives drug	1.38 (1.15-1.66)*	NS	NS
	Antiepileptic	1.88 (1.02-3.49)	NS	NS
	Antihypertensive	(1.06-1.48)*	1.5-1.8	NS
5	**Sensory**			
	Vision impairment	1.35 (1.18-1.54)*	1.3-1.6	1.27 (1.19-1.35)
	Hearing impairment	1.21 (1.05-1.39)*	NS	NS
6	**Neuromuscular**			
	Rheumatic disease	1.47 (1.28-1.70)*	NS	NS
7	**Medical**			
	Urinary incontinence	1.40 (1.26-1.57)	NS	1.08-1.37
	Hypotension	1.24 (0.90-1.71)*	1.2-1.8	NS
	Hypertension	NS	1.5-1.8	0.83-0.94
	Diabetes	1.19 (.08-1.31)*	NS	1.05-1.23
	Pain	(1.19-1.62)*	NS	NS
	Comorbidity	1.23 (1.16-1.30)*	NS	NS
	History of stroke	(1.31-1.98)*	NS	1.28-1.62
	Heart disease	NS	NS	0.99-1.22
	Osteoarthritis	NS	NS	1.24-1.42
	Osteoporosis	NS	NS	1.15-1.34
8	**Environment**	NS	NS	NS

Note: NS = not specified OR = odd ratio, CI = confidence interval, * = indicates significant risk factors

For instance, Malaysia comprised of three major ethnic groups, namely Malays, Chinese and Indians which may require specific investigation of risk factors that might differ from those reports in primarily Chinese population as well. In addition, Malaysia also experiences different weather as compared to other Asian countries like China and Korea, which could contribute to the variation with respect of environmental risk factors. Thus, there are still gaps in identifying specific risk factors that may differ or remains to be investigated in other populations such as Malaysians.

2.4.1 Socio-demographic factors

Based on the previous studies, older age, female gender, history of fall and living alone were the most common socio-demographic risk factors reported to be significantly associated with fall prevalence (Assantachai et al., 2003; Deandrea et al., 2010; Kwan et al., 2011a; Rubenstein, 2006).

2.4.1.1 Age

Age is one of the key risk factors for falls. Previous studies revealed that the chance of falling and severity of fall related injuries increase with advanced age (Ambrose et al., 2013; Campbell et al., 1989; Deandrea et al., 2010). The incidence of falls were reported to be increasing consistently from 30 percent after the age of 65 years up to 50 percent in people aged 80 years and older (Blake et al., 1988; Carter et al., 2000; Prudham & Evans, 1981). A meta-analysis on 74 prospective studies on fall risk factors among older people indicated that advanced age remains and has consistently been identified as one of the main risk factors for falls among western populations. This review revealed that the odds ratio of falling is 1.2 times more for every 5 year increase in age (Deandrea et al., 2010).

Significant increases in rates of falls have been reported with increasing age in Asian populations as well (Eun et al., 2015; Kwan et al., 2011a). An Australian Health Institute and Welfare report indicated that for those aged 75 years and over, fall resulting in serious injury are the leading cause of fatal falls and institutionalisation (Tovell & Harrison, 2013). Generally, advanced age is associated with reduced functional and physiological status. The age related deterioration in a number of psychological and biological systems can affect overall mobility and functional status (Finlayson & Peterson, 2010). The decline in physiological systems such as musculoskeletal, vision, somatosensory, vestibular, coordination, slower reaction time, postural control and cognitive function with increasing age have been reported to increase the risk of falls (Dunlop et al., 2002; Segev-Jacubovski et al., 2011). These changes were supported by findings from the Longitudinal Study of Aging (LSOA) among 4,000 seniors, which indicated that functional status declined within two years interval over a period of six years (Dunlop et al., 2002).

Moreover, older adults are more predisposed to having greater comorbidity compared to younger people, which could lead to increased risk of one or multiple falls (Campbell et al., 1989; Cummings et al., 1988; Tinetti et al., 1988). Conditions that have increased prevalence with increasing age such as Parkinson's disease, osteoarthritis, diabetes, stroke, incontinence and impaired vision are strongly associated with increased risk of falls (Ambrose et al., 2013).

Grundstrom et al. (2012) have investigated risk factors for falls among 12,684 adults age 85 years and above in 50 states in the United States of America. The findings indicated that 21.3% of adults aged 85 years and above experienced at least one fall in the past three months and seven percent reported an injury that required medical attention or restricted their activity for at least a day. This study also identified that being male, below average general health, perceived sleep disturbance, using an assistive device, increased bodyweight, alcohol consumption and history of stroke were found to be independently associated with a greater risk of falls and fall related injuries in this sample. This study revealed that the greater risk of falling appeared due to the deterioration of overall health with age. Interestingly, this study indicated that there was no greater risk of fall in adults aged 85 years and over with excellent overall health status, compared to the 65-84 age group (Grundstrom et al., 2012). This finding supports the concept that age by itself may not be the major contributor to increased falls risk, but that much of this increased risk is associated with increased prevalence of age related health problems.

2.4.1.2 History of falls

Older adults who have experienced one or more falls have three times the risk of falling again within a year compared to non fallers (O'Loughlin et al., 1993; Rubenstein, 2006). Deandrea et al. (2010) identified that those with a history of falls, whether from functional limitations due to a falls-related injury or from fear of future falls, commonly respond by decreasing their overall level of physical activity. This can induce a gradual decline in mobility, increase fragility, and delay the potential to obtain a full recovery and return to prior functional status.

In addition, Barak et al. (2006) have investigated the kinematic changes during walking among 21 older adults with a history of falls in the previous six months and 27 without a history of falling. Findings indicated that those people with a history of falls have increased variability of kinematic measures in their walking coordination and showed less stable gait pattern compared to those without history of falls. This study confirmed that variability of walking patterns among those with history of falls predisposed fallers to have multiple falls in the future (Barak et al., 2006).

2.4.1.3 Gender

Female sex is widely reported in the literature as being associated with increased risk of falls and fall related injury, not only among Caucasian populations but also in Asian studies (Assantachai et al., 2003; Deandrea et al., 2010; Dsouza et al., 2014; Kwan et al., 2011a). Several underlying factors could explain the variation in rates of falls between males and females. This may be due to women being frailer and tending to live longer than men, which make them more susceptible to falls. Furthermore, the muscle weakness and lower levels of physical activity observed in older women may contribute to the propensity of women to fall more often than men (Stevens & Sogolow, 2005). In addition, decreased bone density after menopause predisposes women to be more likely to experience a fracture following a fall.

Dunlop et al. (2002) reported that 58% of female older adults sustained more non-fatal fall related injuries compared to males (42%). However, the fatality rates for male fallers were higher than for female fallers possibly because of the cause or severity of the fall (National Centers for Injury Prevention and Control, 2010). These could be due to the falls circumstance, e.g. that men fall more often from a greater height and/or due to poorer health status at the time of fall. In another related study, women were more likely to report a fall, to seek medical treatment due to fall related injuries, and were more willing to discuss about falls with a physician compared to men (Stevens et al., 2012). The tendency of women to report falls more and to receive medical attention could possibly contribute to the higher rates of falls reported among women.

Similar findings were reported from the 2011 Korean Community Health Survey (KCHS) that identified potential risk factors among 56,624 Korean aged 65 years and over. This study reported that 63.5% of the fallers were female and 36.5% were male. The variation in the fall rates between gender were significantly associated with higher risk of falls (OR =1.17, 95% CI [1.08 - 1.27]), (Eun et al., 2015).

2.4.1.4 Ethnicity /Race

Several studies have revealed a disparity of falls data between different ethnic groups and races (Hua et al., 2007; Kalula et al., 2011; Kwan et al., 2011a). Yet, there is limited evidence from studies that elucidate factors contributing to the influence of ethnic and racial differences in falls prevalence among older adults.

One study in the United States identified that White Non-Hispanic older adults fall more often than Black, Hispanic and other Non-Hispanic older adults, whilst African Americans are less likely than Whites to have a fall (adjusted odds ratio, OR = 0.77, 95% CI = [0.62-0.94]), (Hanlon et al., 2002). Socio-demographic characteristics, health problems, and race differences appear to be crucial risk factors for single and multiple falls in community-dwelling African American and White older adults, with White older adults at greater risk of one-time falls (Hanlon et al., 2002).

A number of studies have reported that Chinese cohorts had approximately 50% lower fall rates compared to western populations (Chan et al., 1997; Chu et al., 2005). A study by Kwan et al. (2013a) has indicated that low fall rates in Chinese cohorts resulted from higher levels of concern about falls and reduced exposure to risk due to more structured activity patterns.

The lack of willingness and preference of not reporting falls could also reflect in the variations seen in reporting falls. For instance, Shin et al. (2009a) found that in the Korean older population, older adults were often not willing to share information about what was considered as a disgraceful experience such a fall with unfamiliar persons, with a fall being perceived as an embarrassing event in their life.

In addition, Caucasian women are significantly more likely than African American women to fall outdoors versus indoors (odds ratio (OR) =1.6, 95% CI =[1.0-2.7]), and laterally versus forward (OR =2.0, 95% CI =[1.1-3.4]), but less likely to fall on the hand / wrist (OR =0.6, 95% CI = [0.3-1.0]). This indicates possible differences in fracture risk in older women of different ethnicities. The differences in fracture risk may be due in part to the different ways in which older Caucasian and African American women fall, rather than how often they fall (Faulkner et al., 2005).

2.4.1.5 Living Arrangements

Living arrangements are one of the socio demographic factors which has been reported to be associated with the prevalence of falls among older people. A prospective study carried out among 666 community dwelling people aged 50 years and above in a rural county in the eastern part of North Carolina found that older people who lived alone of both genders experienced more falls compared to those who lived with others (Elliott et al., 2009).

In Asia, it is a common social norm or practice for older adults to be taken care of by their family members. But due to rapid changes in socio economic wealth and affluence, and transition towards being more like some developed countries, this practice seems to be changing. Informal care giving difficulties are being seen due to the increasing role of women in the employment sector, reduced perception, and value on traditional care, and the increasing trend of the nuclear family. These scenarios have tended to result in more older people in Asia living alone over time (Dsouza et al., 2014).

2.4.2 Psychological factors

2.4.2.1 Depression

Depression among older people commonly develops as a result of the complex interaction of age-associated physiological changes, stressful life events, cognitive and genetic vulnerabilities (Fiske et al., 2009). It has been reported that 15 percent of community dwelling older people have significant depressive symptoms and about two percent present with major depressive symptoms (Blazer, 2003). Older people who suffer from depression are less likely to be involved in physical activity, and are more likely to have low Activities of Daily Living (ADL) level, poor quality of life, and functional dependence (Blazer, 2003; Nyunt et al., 2012; Wada et al., 2005). These factors could contribute to muscle weakness and lead to increased risk of falls.

Studies have also indicated that the use of medications to treat depression (such as serotonin, benzodiazepines) were associated with increased risk of falls (Lindsey, 2009). In accordance to Cesari et al. (2002), a recent cross-sectional study from the 2010 National Social Life and Aging Project examined the relationship of anti-depressant medication and depressive symptoms on fall occurrence among 2338 adults aged 57 years and above. Findings confirmed that older adults who were prescribed with antidepressants and had depressive symptoms had higher risk of falls (Prizer et al., 2015). Therefore, the mechanism of medication related to depression may become an iatrogenic factor that should be investigated and elucidated in the attempt to reduce the risk of falls among depressed older people.

Moderate levels of depression have also been reported in Asian countries (Vietnam, Indonesia and Japan) with prevalence reported between 17.2 to 33.8 percent in adults aged 60 years and above (Wada et al., 2005). This study indicated that those who experienced depression had low ADL performance and poor quality of life (Wada et al., 2005). Furthermore, robust findings from previous studies have reported that presence of depressive symptoms was positively associated with falls among western populations (Deandrea et al., 2010; Tinetti et al., 1988) and Asian populations (Eun et al., 2015; Kwan et al., 2011a). In Malaysia, it was reported that the prevalence of depression among Malaysians aged 60 years and above was approximately 13 percent (Rashid & Tahir, 2014).

Interestingly, in addition to depression, recent findings indicated that higher levels of stress were found to be significantly associated with increased risk of falls among Korean older people. This factor was found to differ from what has been reported in previous systematic reviews and meta-analyses on falls risk factors (Deandrea et al., 2010; Kwan et al., 2011a). Despite stress levels being rarely reported and not commonly investigated by previous studies, it was noted that higher levels of stress was reported to be a trigger factor for falls, and was subsequently related to hip and pelvic fractures (Fink et al., 2014; Moller et al., 2009). Therefore, further investigation should be undertaken in various populations to verify the significance of this possible risk factor.

2.4.2.2 Fear of falling

Fear of falling is characterised by anxiety related to walking or a concern about falling as a psychological consequence which may be related to a previous fall or be associated with poor balance ability. A population based study indicated the prevalence of fear of falling among older person was 43 percent (Lach, 2002).

Among Asian populations, fear of falling has become one of the emerging health problems for older people. In India, a study measured fear of falling using the short form Falls Efficacy Scale- International (FES-I), and found that the prevalence of fear of falling among 250 people aged 60 years and over who lived in urban areas was 33.2 percent (Mane et al., 2014). This study indicated that fear of falling significantly correlated with activities reduction, history of falls in the previous six months, lower educational status, family living arrangements, and depression. In a similar study, fear of falling was reported in 76.6% older Koreans (Kim & So, 2013).

Furthermore, a recent study conducted in Taiwan investigating the incidence, characteristics and risk factors for fear of falling among 3284 community dwelling people aged 65 year and above, indicated more than half of the participants reported fear of falling. The study also identified that fear of falling was most prevalent among female as compared to male participants. In addition, the prevalence rate of falls regardless of gender differed for those who experienced fear of falling, being significantly higher compared to those without fear of falling. The study concluded that history of falls, female gender, low perceived health, insomnia and depression were correlated to fear of falling (Chang et al., 2016).

Consistent with these findings, the review by Kwan and colleagues (2011a) identified that fear of falling was a significant risk factor for falls, with odds ratios ranging from 1.9 to 3 in six fall studies among Chinese populations. Interestingly, this review also indicated that one study has reported that fear of falling was found to be a protective factor for falls (Zhang et al., 2005). This discrepancy was considered to possibly be attributed to the adaptive behaviours among the studied population by decreased risk taking behaviour and being less engaged in unplanned activities.

From these findings, it can be concluded that fear of falling is a common problem related to falls among older people in Asian countries as well as western countries, even though there is limited research carried out investigating contributors to fear of falling in Asian populations. Therefore further investigation should be undertaken to identify associated risk factors which contribute to the prevalence of fear of falling in order to inform effective interventions to reduce this important risk factor for falls.

2.4.3 Balance and mobility impairment

Balance is essential for mobility and performing activities of daily living. Gait and balance impairment have been consistently reported as among the strongest risk factors for falls among community dwelling older people (Ambrose et al., 2013; Deandrea et al., 2010; Kwan et al., 2011a; Lord et al., 2007; Muir et al., 2010; Tinetti et al., 1988). Decreased muscle strength, less flexibility (stiffness) and reduced coordination of postural control could lead to poor gait pattern and balance impairment among older people. Overall, older people with balance and/or gait impairment are twice as likely to fall as those without balance and/or gait impairment (Deandrea et al., 2010). Similar findings were reported among Chinese populations. Kwan et al. (2011a) in their review indicated that five studies have reported significant associations between balance impairment and falls among Chinese populations. Balance and mobility impairment (incorporating static (standing balance) and dynamic balance (e.g. functional reach test, sit to stand test), and gait (e.g. Timed Up and Go test) were found to be significantly associated with increased risk of falls by 1.4 to 2.6 times among Chinese older populations (Kwan et al., 2011a). However, high heterogeneity between studies due to inconsistency in measurements of muscle weakness and balance impairment was reported in the Deandrea et al. (2010) review, who could not establish a risk for balance and gait impairment risk factor firmly. Furthermore, limited numbers of balance and gait assessment have been conducted among Asian populations. Therefore further investigation and intervention should be carried out to fill the existing gap.

In addition, poor mobility that is often associated with musculoskeletal or neurological impairments may contribute to gait abnormalities, impaired postural control, and poor functional balance (Axer et al., 2010; Barak et al., 2006; Bhatt et al., 2011; Chu et al., 2006; Lord et al., 2011; Muir et al., 2010). The ability to maintain balance during navigation in daily activities is a key component of successful ambulation. Balance impairment, gait impairment and lower limb muscle weakness are important factors associated with reduced functional mobility and dependency in daily tasks among older people (Ribeiro & Oliveira, 2010). Deterioration of muscle strength, slower reaction time and presence of pain have been shown to affect balance and motor performance (Ribeiro & Oliveira, 2010). Neurological conditions which result in gait dysfunction, such as stroke, Parkinson's disease, cerebellar disorders and hypothyroidism, increase an older adult's risk for falls.

Age related changes in the walking pattern have generally been interpreted as indicating the adoption of modified gait to increase gait stability (Barak et al., 2006; Jerome et al., 2015; Shkuratova et al., 2004). However, other than age, variability in the gait deficits observed in older adults such as increased stride width, reduced walking speed and stride-to-stride variability are independent predictors of falling (Barak et al., 2006; Campbell et al., 1989; Hausdorff et al., 2001; Jerome et al., 2015) which may be influenced by cognitive function or psychological aspects such as depression, anxiety or fear of falling (Justine et al., 2014).

An aspect of balance impairment that has had relatively little focus in the research literature is having difficulties during turning (Dite & Temple, 2002a). Compared to regular walking, falls while turning are eight times more likely to result in hip fracture than falls when walking straight (Cumming, 1998), and have also been found to be associated with greater risk of slip-related falls (Nagano et al., 2013). Turning is an essential gait related activity involved in regular daily functional tasks. One study reported that 20% of steps during indoor daily activities involve turning (Sedgman et al., 1994). Another study evaluating turning in four community activities, including walking through a cafeteria, through a convenience store, and from a specific office to a car in the parking lot, found that between 8-50% of steps involved turning manoeuvres (Glaister et al., 2007). These findings emphasise the importance of turning in daily ambulation.

Turning has also been shown to be a more challenging aspect of gait compared to straight-line walking (Segal et al., 2008a) and the ability to maintain balance during turning is complex (Hase & Stein, 1999). Turning is a movement which requires an individual to transport the body's mass while maintaining a state of stability in order to change direction during ongoing locomotor trajectory (Akram et al., 2010; Orendurff et al., 2006). The process of turning consists of deceleration of forward motion, trunk rotation and stepping out towards new direction (Glaister et al., 2007). This is accomplished in three consecutive steps: approach, pivot, and acceleration steps embedded within two phases Thus, postural adjustment is critically dependent on integration of sensory input and requires high demand of neuromuscular control (Orendurff et al., 2006; Segal et al., 2008b; Simpson et al., 2002).

Previous research has reported that older people show less stability while turning (Thigpen et al., 2000). For example, Baird and Van Emmerik (2009) examined turning performance in older people and young people during an in place turning task.

Findings indicated that older people had greater postural instability and used more foot movements to sustain postural stability while performing the turning task. In another related study, Dite and Temple (2002a) found that older people with a history of falls took more steps and required longer time to complete a 180 degree turn during performance of the Timed Up and Go test, compared to those without a history of falls. There has been limited assessment procedures suitable for clinical practice reported in the research literature (Table 2.5)

Despite the importance of turning as an essential gait related activity involved in daily functional tasks, there has been relatively little study related to turning in older people conducted. Further investigation on the impact of turning on falls, and falls related injuries such as hip fractures are required.

2.4.4 Medication

The number of medications taken by older adults and the associated falls risk have received considerable attention of researchers and healthcare providers. With the general increase in prevalence and severity of health problems in older adults, medication use also increases with advancing age. Polypharmacy (taking more than four medications) is an independent factor that commonly has been reported to increase the risk of initial or recurrent falls among older people (Hammond & Wilson, 2013; Hartikainen et al., 2007; Kojima et al., 2012; Ziere et al., 2006). Similar findings were also reported in the Deandrea and colleagues meta analyses, which indicated that an increase in one medication is likely to increase the odds of experiencing a fall (Deandrea et al., 2010).

Similar findings were reported in a recent study based to the prospective Irish Longitudinal study on Ageing among 6,666 adults aged 50 years and above. This study found that polypharmacy, including antidepressant use, was significantly associated with greater risk of injurious falls and increased number of falls in middle-aged and older adults (Richardson et al., 2015). Furthermore, a review of 29 studies, consisting of 28 observational studies and one randomised controlled trial, concluded that psychotropic medications, such as benzodiazepines, antidepressants, and antipsychotics, were associated with falls (Hartikainen et al., 2007).

Woolcott et al. (2009) conducted a meta-analysis to identify the association between falls and medications. Out of 11,118 articles, 22 articles were analysed with nine relevant drug classes included in the analyses. The study concluded that sedatives and hypnotics, antidepressant and benzodiazepines drugs were significantly associated with falls among older people. More recent evidence has suggested that polypharmacy solely may not be as important as a risk factor for falls. The effect of medication on fall risk factors was shown to be more related to the types of medication (e.g. benzodiazepine, digoxin, central analgesic) which were significantly associated with increased risk of falls (Hammond & Wilson, 2013). Furthermore, polypharmacy is often an indicator reflecting the underlying multiple medical conditions experienced by older people, that predisposes them to higher risk of falls (Lord et al., 2007).

In addition to the number and type of medications taken, certain classes of medications contribute to falls risk due to side effects of the medication. Some of the more common side effects of medications that may be associated with increased risk of falls include blurred or impaired vision, sedation or decreased alertness, confusion and impaired judgment, delirium, compromised neuromuscular function, anxiety, or hypotension leading to dizziness and light headedness (Chen et al., 2014).

2.4.5 Sensory and neuromusculoskeletal risk factors

The somatosensory, vestibular and visual systems are responsible for receiving sensory information and transmitting information via afferent nerves to the central nervous system. The integration of these systems is important in maintaining balance (Shumway-Cook & Horak, 1986), and to defend against falls.

2.4.5.1 Somatosensory impairment

The responsive capability of the somatosensory system was shown to be inversely correlated with aging (Shaffer & Harrison, 2007). There is an association of the structural and functional decline of the somatosensory and/or central nervous systems which potentially contributes to increased postural instability in older adults. This can cause diminished touch and texture sense, decreased response to vibration (Richardson & Hurvitz, 1995; Wickremaratchi & Llewelyn, 2006) and impaired joint position awareness, all of which are associated with an increase in postural sway, a strong indicator of standing balance. The following independent risk factors for falls are related to the somatosensory system: impaired ankle tactile sensitivity, reduced knee vibration sense and impaired joint position (Shaffer & Harrison, 2007; Woollacott et al., 1986). In addition, there is also a strong association between distal limb neuropathy and falls with those with electromyographically identified peripheral neuropathy having a far more likely chance of falling and repetitive falling (Richardson & Hurvitz, 1995). Therefore, effective functioning of the somatosensory system is important to evaluate when determining falls risk insofar as these deficits may negatively impact the older adult's safety, body position awareness, and/or muscle reaction to a perturbation while in a balanced position during functional activities (Lord & Ward, 1994).

2.4.5.2 Vision impairment

The Deandrea and colleagues meta-analyses showed that older adults with visual impairment are 1.4 times more prone to falls compared to those who did not have visual impairment (Deandrea et al., 2010). Similar findings were reported among older Chinese populations (Kwan et al., 2011a). With respect to age-related visual system deficits, the eyes undergo physiological changes which result in poor lens elasticity, reduced lens transparency, decreased visual acuity, low contrast sensitivity, and decreased accommodation during lighting variations (Gittings & Fozard, 1986). These impairments are common among older adults as they accompany cataracts, macular degeneration and glaucoma. Older adult fallers may rely more on visual cues to recognize and correct postural deviations during dynamic activities as compared to non fallers (Cromwell et al., 2002), possibly resulting from reduced age and health-related proprioceptive and vestibular impairments (Lord & Webster, 1990). This finding suggests that visual input is an important factor in maintaining postural stability in older adults.

An increase in sway during standing when visual input is altered or removed may in part account for this increased risk (Woollacott et al., 1986). In a cross-sectional survey of eye disease with a retrospective collection of falls information, tests of visual function associated with two or more falls were contrast sensitivity and visual acuity (Attebo et al., 1998; Ivers et al., 1998).

2.4.5.3 Vestibular impairment

The vestibular system provides information about the position of the head in space, and head movement with respect to gravity and inertial forces. Deterioration in vestibular function can cause feelings of unsteadiness, light headedness, violent spinning sensation (vertigo) or dizziness, all commonly associated with falling in older adults. Older adults with vestibular dysfunction have greater risk of falling (Agrawal et al., 2009; Baloh et al., 2001; Herdman et al., 2000). Similar to the somatosensory and visual systems, age effects occur in the vestibular system, such as 40% reduction in hair cells for those over the age of 70, a progressive loss of nerve fibres in the peripheral vestibular system and an overall decline in vestibular system function (Baloh et al., 2001; Dieterich & Brandt, 2001).

Herdman et al. (2000) indicates that the incidence of falls in those aged 65 to 74 years of age with increased bilateral vestibular dysfunction is 26.1% greater than age-matched community dwelling older adults with normal vestibular function. In addition to age related effects, pathology of the vestibular system also results in degeneration of vestibular function and associated symptoms, for example, benign paroxysmal positional vertigo (BPVV), Meniere's diseases, and vestibular neuritis (Ekvall Hansson & Magnusson, 2013; Gazzola et al., 2006; Herdman et al., 2000). The Deandrea and colleagues meta-analysis reported a significant increase in risk of falls associated with dizziness and vertigo (Deandrea et al., 2010). Furthermore, the vestibular impairment was also reported as a mediator risk factor for falls among diabetes patients, and increased risk of falls two fold compared to those who did not have diabetes (Agrawal et al., 2010).

2.4.6 Medical conditions

A number of studies have identified a range of medical conditions that are associated with increased risk of falls. Similar findings were reported regarding types of medical conditions and chronic illnesses which were significantly associated with falls in both Western and Asian populations (Deandrea et al., 2010; Kwan et al., 2011a; Sohng et al., 2004). Both reviews indicated medical conditions such as diabetes mellitus, stroke, urinary incontinence, rheumatic disease, dizziness and vertigo, pain and Parkinson's disease were significantly associated with the prevalence of falls.

2.4.7 Environmental factors

Environmental factors are extrinsic risk factors that can be strongly associated with increased risk of falls. Previous studies indicate that 30-50% of fall prevalence among community dwelling older people result from environmental factors (Braun, 1998). Lord et al. (2007) reviewed a number of studies examining the association between environmental hazards and falls and found that environmental risk factors could contribute to falls in older people, but were often not solely the cause of falls. Moreover, falls that involve an environmental contribution might often result from interaction between an individual's physical capability and the environmental hazards, rather than simply the environmental threat alone (Lord et al., 2007).

2.4.8 Summary of risk factors for falls

In conclusion, even though there are a large number of epidemiological studies that have established significant risk factors for falls in older people, most of these studies were focused among Western populations. Recently there has been some limited evidence arising from investigations of falls risk factors in Asian populations, although the majority of these data are from retrospective studies. There are many common risk factors evident between populations from western and Asian countries, however the available studies currently also highlight some risk factors that appear to differ between western and Asian countries (marital status, psychological aspects relating to falls such as depression, and physical inactivity) or where the risk factor has not been well investigated in Asian countries (e.g. cognitive and education background, physical activity, postural balance, function and mobility, environmental factors). Furthermore, fall risk factor studies in Asia have primarily focused on Chinese ethnicity, and there is a need for similar studies in other major ethnicities such as Indian and Malays across Asia. Given consideration to the above findings, there appear to be some differences in risk profile between countries, it is likely to be important for identification of fall risk factors in specific populations that differ from those where existing risk factor studies have been conducted, to ensure targeting of the most culturally and ethnically relevant falls risk factors and interventions.

2.5 Fall risk assessment

Due to the devastating consequences of falls to older adults and society, considerable efforts have been devoted to implementing and evaluating fall prevention programs. A commonly used basis for targeting risk factors in fall prevention programs has been to undertake a detailed fall risk assessment, to identify those who are at risk of falls, and to identify what mix of risk factors are most relevant to target for an individual.

The terms of "falls risk assessment" and "falls risk screening" are common used interchangeably. Fall risk assessment refers to the process which mainly aims to identify factors that increase risk of falls which could be reduced with subsequent intervention, whereas screening is primarily focussed on identifying individuals who are at risk of falls (Close & Lord, 2011). Generally, a detailed falls risk assessment may consist of questions regarding history and circumstances of falls, physical examination, gait and functional mobility performance, postural stability and balance, medical conditions and medication review, muscle strength, sensory evaluation, and blood pressure.

At present, there are number of fall risk assessment tools that have been evaluated for one or more psychometric properties, as listed in Table 2.4, and used as an initial step to reveal the causative factors and associated risk for falls in various populations prior to development of a suitable individualised fall intervention (Lee et al., 2013a; Perell et al., 2001).

However, it is important to note that while some falls risk assessment tools have been investigated for their reliability and validity in specific settings, there are some in use have not been standardised within or across various settings (Lee et al., 2013a). Furthermore, assessment tools that have been validated in one setting (e.g. community) may require some modification and re-evaluation of validity in other settings (i.e. it is unlikely that the same falls risk assessment tool will be equally effective in community and hospital settings). Therefore the usefulness of the assessment tool in predicting falls may vary depending on the health status and level of function among the studied population (Lee et al., 2013b).

Thus, selecting a validated assessment tool for the specific population being considered is important. According to Perell et al. (2001), it is recommended to use a screening or assessment tool that meets the following criteria: high sensitivity, specificity, inter-rater reliability, similarity of population in which the tool was developed; standardised written procedures which outline the appropriate use of the tool; feasible time requirements to administer the tool, and to provide cut off points to identify increased or high risk, indicating the need for appropriate interventions.

In a more recent review, Lee et al. (2013b) identified 16 fall risk assessment tools that have been used and validated to assess fall risk in the community setting.

Table 2.4: A selection of validated fall risk assessment tools reported in the community setting

Tools	**Developed**	**Population tested**	**Measured risk factors**	**Validity / reliability**
FROP-Com Falls Risk for Older People – community version (Russell et al., 2008)	Australia	Older community dwelling presenting to an emergency department after a fall	History of fall, medications, medical conditions, sensory loss, foot problems, cognitive status, continence, nutritional status, and function. Score = (0-60) Cuts off score >18 indicated high risk of falls	Sensitivity 71.3%, Specificity 56.1% Inter rater reliability (ICC = 0.93) Test retest reliability (ICC = 0.91)
Fall Risk Assessment Tool (Nandy et al., 2004)	United Kingdom	1000 people aged 65 years and above at primary Care center	History of falls, medications, psychological and cognitive status. Total score = 20	high specificity (0.92, 95% CI 0.88–0.94) and a positive predictive value of 0.57 (0.43–0.69); low sensitivity (0.42, 95% CI 0.32–0.54) and negative predictive value (0.86, 0.83–0.89)

Note: FRAT = Fall Risk Assessment Tool, ICC = Intraclass Correlation Coefficient;

Table 2.4.: (continued). A selection of validated fall risk assessment tools reported in the community setting

Tools	Developed	Population tested	Measured risk factors	Validity / reliability
FallScreen© Physiological Profile Assessment (Lord et al., 2003)	Australia	Community dwelling	Vision, peripheral sensation, lower limb strength, body sway and reaction time. Score 1 or more indicates increased risk of falling.	79% of accuracy Reliability ICC= 0.82 (0.69-0.89 at 95% CI)
QuickScreen (Tiedemann et al., 2012)-	Australia	Community dwelling	History of fall, medication, visual acuity, tactile sensitivity, lower limb strength and balance.	test-retest reliability (ICC coefficient ranged 0.54-0.89)
Thai FRAT (Thiamwong et al., 2008)	Thailand	Community dwelling	History of falls, balance, gender, vision and vison acuity, medication, environment focus on “Thai house”. Score ranged from (0 to 11) with cut off = 4	Sensitivity = 0.92 Specificity = 0.83

Note: FRAT = Fall Risk Assessment Tool, ICC = Intraclass Correlation Coefficient;

While their review indicated that there is moderate evidence of usefulness of fall risk assessment applied in community settings, they suggested further development of fall risk assessment should address this gap and for future intervention. Of note, most of the falls risk assessment tools were developed and tested among western populations. Additionally, Dsouza et al. (2014) has highlighted that differences in aspects of culture, language, environment, lifestyle, and socioeconomic variables between Asian populations and Western populations could possibly affect the suitability and acceptability of a falls risk assessment tool between populations. For instance, a traditional practice such as rising from sitting on the floor is a common daily task among some Asian communities, including older people, which is a relatively uncommon practice and therefore not routinely assessed among western populations. There is a need for further investigations on the use of established fall risk assessment tools developed in Western countries as to suitability and applicability in assessing risk for fall in the other populations.

2.5.1 Assessing balance and mobility performance

Balance refers to the individual's ability to maintain the centre of gravity of the body vertically over the base of support (Shumway-Cook et al., 2007; Woollacott et al., 1986). Balance is a complex process and encompasses sustaining postures, initiating movement, and recovering equilibrium utilising integration of sensory input (visual, vestibular and somatosensory system) and coordinating subsequent motor output (Mancini & Horak, 2010). Due to the complexity of balance between individuals, previous studies have recommended that balance assessment should be measured across different domains and be obtained from more than single measures (Bernhardt et al., 1998; Sibley et al., 2011). Further understanding and identifying of underlying mechanisms that are related to balance performance of individuals is an essential aspect prior to implementing appropriate interventions to improve balance and mobility performance and reduce risk of falling (Horak, 2006; Sibley et al., 2011).

Balance can be classified into static and dynamic balance. Static balance refers to the ability to maintain steady posture without any voluntary movement of the base of support (BOS). Dynamic balance refers to the ability to maintain equilibrium of the Centre of Gravity (COG) during active movement either voluntary or as response to an external perturbation. The most common method for classifying balance measurement is referring to the complexity of the balance task. The balance complexity can be increased in challenge by narrowing base of support, as well as altering sensory information. For instance, maintaining balance during bilateral standing with feet together (narrow base support) will be more challenging than feet apart (wider base support). Meanwhile standing on a firm surface is easier than standing on a foam surface. In addition, the level of challenge and complexity of balance tasks could be varied from a simple static single task such as static stance to dynamic task performed simultaneously with an additional task (dual task) or additional multiple tasks (multitasking).

A prospective study conducted among 29 stroke patients, undergoing rehabilitation to improve balance has indicated that dynamic balance tasks showed more responsiveness to change over time compared to static balance tasks. Based on the factor analysis performed in this study, a number of balance measures were grouped into static, and dynamic single limb stance and dynamic bilateral stance tasks (Bernhardt et al., 1998).

Mancini and Horak (2010) conducted a review indicating that clinical balance assessments are able to discriminate the various types of balance impairment, while physiological approaches are able to determine the underlying sensorimotor mechanisms that contribute to balance dysfunction. Objective measurement of balance using computerised systems and / or wearable inertial devices may provide more accurate, responsive, and sensitive balance assessment.

Given the large number of balance assessment tests available, it is important to ensure an appropriate selection of measurements to comprehensively assess underlying balance impairment and assist in defining an effective intervention (Bernhardt & Hill, 2005). Table 2.5 lists a common balance and mobility measures used for community dwelling older adults. The capacity of measurement tools in discriminating individuals with various balance conditions, as well as in evaluating the effectiveness of intervention programs should be important factors in the process of selecting the most appropriate suite of measurement tools for a specific sample. Thus, a comprehensive clinical assessment of balance, utilising an appropriate selection of tests relevant to the population or severity of balance dysfunction, plays an important role in revealing underlying level and type of balance impairment that can be used as a basis for rehabilitation purposes.

Table 2.5: Lists common balance and mobility measures reported in the community setting

Tool	Measures	Validity/ reliability
Timed up and Go (TUG), (Podsiadlo & Richardson, 1991)	Used to assess mobility, balance , walking ability and falls risk in older adults. Simple balance test based on the timed adaption to perform 3 meters walking from seated position and return to the chair.	Excellent inter-rater (ICC=0.99) and test retest (ICC = 0.99) reliability.
Activities-Specific Balance Confidence Scale (ABC), (Powell & Myers, 1995)	Used to measure self perceived confidence on balance while performing. A 16 items questionnaire in which subjects rate their confidence that they can maintain their balance in the course of daily activities. Items are rated from 0% (no confidence) to 100% (complete confidence) and averaged.	Good test-retest reliability (ICC ranging from 0.7 to 0.92)
Balance Evaluation SystemsTest (BESTest), (Horak et al., 2009)	Consists of 36 items, grouped into six systems: i) Biomechanical Constraints, ii) Stability Limits, iii) Anticipatory Postural Adjustments, iv) Postural Responses, v) Sensory Orientation, and vi) Stability in Gait. Each item is scored on a four level, ordinal scale from 0 worst performance) to 3 (best performance).	Good inter-rater reliability (ICC=0.91). Moderate correlation with ABC Scale was r=.636, P<.01
Berg Balance Scale (Berg et al., 1995)	Used to identify balance impairment by assessing of functional tasks performance. A 14 item of functional activities including sitting, standing, transferring, turning. Item scored from 0-4 with a maximum score of 56 with maximum score of 56. A score <45 is associated with increased risk of falling.	Good reliability (96% of non- faller were classified). Excellent test-retest reliability (ICC= 0.91) and intra rater reliability (ICC= 0.97).
Tinetti Balance and Gait Assessment (Tinetti et al., 1986)	Used to measure gait and balance based on task performance exam. A 14 item of balance and 10 item gait test. Maximum score is 40 and individual with score <36 are greater risk of falling.	Excellent sensitivity (93% of faller were classified) Good inter rater reliability (85%).
Functional Reach Test (Duncan et al., 1990)	Used to evaluate of dynamic balance test of reaching ability in bilateral stance (self-generated perturbation). Subjects were asked to standing along a wall, holding arms in front, and then has to lean forward as far as they can. The distance covered by the extremity of the major finger along a horizontal ruler will be measured.	Good to excellent reliability, inter rater reliability (IC = 0.98), test-retest reliability (ICC = 0.92). Excellent predictive validity of subject at risk of falls.

However, there are some aspects that should be considered prior to selecting balance measurements such as reliability and validity of measurements, administration factors including cost, time and skill, and population or sample characteristics where the measurement will be applied (Berg, 1989). The selection of appropriate measurement for a specific population is important to minimise ceiling effect or floor effects of the measurement. Ceiling effects occur when most participants are able to achieve maximum scores due to the measurement being too easy, and floor effects are when most participants are not able to obtain a score on a measurement because of the difficulty of the assessment task.

In the present thesis, two broad forms of measurements were conducted to assess balance and mobility performance: i) clinical measures, and ii) laboratory measures using the computerised Neurocom™ Balance Master long force platform (Bock & Beurskens, 2010; Suttanon et al., 2012; Yang et al., 2012).

Clinical measures of balance are easy to use, quick to administer, able to predict risk of falls and do not require expensive equipment, as compared to computerised balance measures. However, some clinical measures of balance have been reported to provide less objective results, suffer of ceiling effects and not be responsive to measuring small improvements or deterioration of balance (Beauchet et al., 2011; Muir, 2009; Muir et al., 2010). However, other clinical measures have been shown to address these limitations (e.g. the Step Test, Four Square Step Test) (Bongers et al., 2015; Carty et al., 2015; Cho et al., 2004)

In summary, balance assessment is complex, and needs to be investigated using an assessment suite that comprises the key domains of balance (static, dynamic bilateral stance, dynamic single limb stance tasks) and may include both clinical, and where appropriate and available, laboratory assessment including force platform measures.

2.6 Fall prevention among community dwelling older adults

Given the extent of consequences of falls and fall related injuries among older people, and the rapidly increasing number of older people in the developing/ Asian countries, further attention towards fall prevention among these populations should be undertaken to address the gap in this current literature (Dsouza et al., 2014; Hua et al., 2007; Jagnoor et al., 2013; Kalula et al., 2011). There is a strong evidence base that a range of interventions are effective for falls prevention among community dwelling older adults (Gillespie et al., 2012). However, most of the established evidence on effective fall prevention interventions has been conducted in Western populations. The evidence of effectiveness of fall prevention interventions that aimed to reduce incidence of falls among older people in the community has been summarised by Gillespie et al. (2012) in a Cochrane review which comprised 159 randomised controlled studies with a total of 79,193 participants. Based on the existing Cochrane review, only 15 (9%) out of the 159 RCTs were conducted in the Asian region (Gillespie et al., 2012). Of the 15 randomised controlled trials, conducted in Asian countries, (Japan, n=6; (Iwamoto et al., 2009; Kamide et al., 2009; Sato et al., 2005; Shigematsu et al., 2008; Suzuki et al., 2004; Yamada et al., 2010),Taiwan n=6; (Huang et al., 2010; Huang & Acton, 2004; Huang & Liang, 2005; Huang et al., 2011; Lin et al., 2007; Shyu et al., 2010), Thailand, n=2; (Assantachai et al., 2002; Jitapunkul, 1998), and China, n=1 (Woo et al., 2007). This review shows that the evidence based intervention on fall prevention among Asian populations is still scarce (Gillespie et al., 2012).

In the present thesis, the interventions for the prevention of falls have been classified according to the Prevention of Falls Networks Europe (ProFaNE) classification as (i) single intervention, (ii) multifactorial intervention (consist of two or more interventions, aimed at an individual's risk factors identified in fall risk assessment), and (iii) multiple interventions (more than one intervention applied to all participants), based on the number, types and combination of interventions utilised, such as exercise, education, psychological, environment / home modification, medication review and surgery and nutritional interventions (Lamb et al., 2011).

2.6.1 Single interventions

Single intervention refers to the application of only one type of intervention that is delivered to all participants. Single interventions were further classified into eight categories as described according to the ProFaNE classification as (i) exercise, (ii) medication, (iii) surgical intervention (cataract, cardiac pace maker), (iv) assistive technology/environmental, (v) nutritional/ fluid therapy, (vi) education and knowledge intervention, (vii) incontinence intervention, and (viii) psychological intervention. The 2012 Cochrane review of falls prevention in the community setting reported 59 single interventions among the 159 included randomised controlled trials. Single interventions that have been reported to reduce the rate of falls are exercise, gradual withdrawal of psychotropic medication, cataract surgery, footwear, and pacemaker insertion (in people diagnosed with carotid sinus hypersensitivity), while home safety assessment and modification has been found to reduce the rate and risk of falling (Campbell et al., 2005; Gillespie et al., 2012). In addition, the use of two sets of glasses rather than bi/multifocal lenses seems to be effective in reducing falls only among older persons who actively engaged in outdoor walking activity (Haran et al., 2010).

While in Asia, exercise interventions (n=8) were found to be most prevalent intervention type that had more than one randomised controlled trial. However, only two studies (Suzuki et al., 2004; Woo et al., 2007) comprised of group exercise and Tai Chi provided positive outcome. Both studies fulfilled the two key criteria such as minimum 50 hours exercise dosage as well as encompassed moderate to high challenge of balance (Sherrington et al., 2011). The remaining six trials were not successful in reducing falls rate or risk of falls (Huang et al., 2010; Iwamoto et al., 2009; Kamide et al., 2009; Lin et al., 2007; Shigematsu et al., 2008; Yamada et al., 2010). They included resistance training, Tai Chi, home exercise programs (individualized, flexibility, strength and balance exercises), square stepping exercise, combined centre based and home based calisthenics, balance, power and walking home based programs, and a combined exercise class and trail walking program.

2.6.2 Multifactorial interventions

Multifactorial interventions are those where the intervention consists of a combination of two or more types of intervention delivered to participants based on their individual risk factors, and usually based on a falls risk assessment tool or assessment. Multifactorial interventions that are linked with specific predisposing and precipitating factors identified from multifactorial assessment have been shown to be effective in reducing falls (Tinetti, 2003). Potential multifactorial interventions included combinations of exercise programs, medication review, vitamin D and calcium supplementation, prescription of assistive walking devices or suitable footwear and referral to healthcare professionals for treatment. According to Gillespie et al. (2012), multifactorial interventions which include individual fall risk assessment are significantly reduced rate of falls by 23 percent (RaR =0.76, 95% CI = [0.67 to 0.86]) but was not effective in reducing risk of falling (RR = 0.93, 95% CI = [0.86 to 1.02]).

Four multifactorial falls intervention studies in the 2012 Cochrane review were conducted in Asia Huang 2004 (Huang & Acton, 2004; Huang & Liang, 2005; Jitapunkul, 1998; Shyu et al., 2010). Only one trial reported to be successful in reducing risk of falls among patients with hip fractures. Shyu et al. (2010) conducted a multifactorial intervention which consisted of three components namely geriatrician review, rehabilitation and discharge planning service. The trial showed a significant improvement after two years follow up in the intervention group relative to the control group on ADL, walking ability, less depression and better SF-36 score. A robust interdisciplinary model of pre and post surgery care appeared to be a key contributor to the positive outcomes from this study.

2.6.3 Multiple interventions

Multiple interventions refer to interventions consisting of a fixed combination of interventions delivered to all participants in the study. The Cochrane review has 19 studies, with seven being effective for rate of falls; and five effective out of 18 studies for number of fallers. The Cochrane review shows for multiple interventions that there is a borderline significant result for falls rate, and non significant for number of fallers. Multiple interventions that were found to be significant in reducing rate of falls were: (i) a combination of exercise, education and home assessment intervention, and (ii) a combination of exercise and nutritional supplementation (targeted at women with calcium and Vitamin D deficiency). In addition, a combination of (i) exercise and vision assessment, (ii) exercise and home safety assessment and (iii) exercise, vision assessment and home safety assessment, were reported to be effective in reducing risk of falling (Gillespie et al., 2012).

Based on the 2012 Cochrane review, there are three multiple intervention randomised controlled trials from Asian countries (Assantachai et al., 2002; Huang et al., 2010; Huang et al., 2011). However, only one trial conducted by Assantachai et al. (2002), providing education using a brochure focused on a number of important falls risk factors and access to a geriatric clinic was effective.

2.6.4 Successful interventions from RCTs since the Cochrane review

The most recent Cochrane review of falls prevention interventions in the community setting is now four years old. A number of new randomised controlled trials that have reported a reduction in fall related outcomes have been published since this Cochrane review. The type of the interventions that have been shown to be effective in recent randomised trials need to be considered in conjunction with the 2012 Cochrane review (Gillespie et al., 2012).

Growing evidence from recent randomised controlled trials on fall intervention programs indicated that there have been some innovations in implementing exercise interventions to become more interactive and less supervised. Recently, there are a numbers of trials that have demonstrated the effectiveness of interactive exercise using videogame technology (Schoene et al., 2013), I-STOP Fall (Gschwind et al., 2015), Wii Fit (Chao et al., 2015), and exergaming (Hasselmann et al., 2015) which were reported to be effective on improving functional status as well as cognitive functions associated with falls among older people. Findings from these studies provide new approaches and options in falls prevention using unsupervised interactive cognitive based interventions to reduce risk of falls (Schoene et al., 2015).

Furthermore, an on-going randomised controlled trial in Malaysia, the Malaysian Assessment and Intervention Trial (MyFAIT), is the first multifactorial fall intervention trial designed to reduce falls among 300 community dwelling Malaysian fallers aged 65 years and above (Tan et al., 2014). The intervention group will be prescribed individualised intervention programs by the medical specialist which focus on six modalities consisting of cardiovascular intervention, fall education, Otago exercise (Campbell et al., 1997b), visual intervention, home hazard intervention and medication review. The primary outcome measure will be fall recurrence measured with monthly falls diaries and falls risk factors; and psychological measures including fear of falling, and quality of life.

2.7 Exercise interventions

From the interventions described above in section 2.6 above, it can be concluded that exercise plays an important role as a single intervention and has also been shown to be most common falls prevention intervention evaluated in the Asian region. Based on the Gillespie et al. (2012) review, eight out of 15 RCTs conducted in Asia were exercise interventions, and exercise interventions also form part of the majority of the successful single, multiple and multifactorial interventions for falls prevention among older people. Thus, exercise interventions have been based on current falls prevention meta-analyses (Gillespie et al., 2012; Howe et al., 2011) and best practice guidelines, e.g. Preventing Falls and Harm from Falls in Older People: Best Practice Guidelines for Australian Community Care, (ACSHQC, 2009). Sherrington and colleagues have highlighted the importance of type and intensity of the exercise applied in their two systematic reviews and meta-analyses that focused on evaluating the effectiveness of exercise in preventing falls (Sherrington et al., 2008; Sherrington et al., 2011). These reviews (the latter including 54 randomised controlled trials) identified that exercise interventions which incorporated challenging balance exercise, and a total duration of exercise of more than 50 hours were most likely to be effective in reducing the rate of falls among older people in the community.

Howe and colleagues conducted a meta-analysis and systematic review to determine the effectiveness and the types of exercise interventions to improve balance performance (Howe et al., 2011). This review analysed 94 studies of exercise interventions on improving balance, with the total of 9821 participants aged 60 years and above from the community (79 studies), institutions (11 studies), and mixed settings (4 studies). Of the 94 studies, 17 studies included in this review were conducted with Asian populations. The review summarized and classified the exercise interventions into eight categories which are i) Gait, balance, coordination and functional task, ii) Strengthening exercise, iii) 3D exercise (Tai Chi, Qigong, Yoga, dance), iv) general physical activity (walking), v) general physical activity (cycling), vi) computerized balance training using visual feedback, vii) vibration platform training, and viii) multiple interventions (consisting of a combination of the above exercise types). This classification was developed based to the exercise taxonomy provided by ProFaNE (Lamb et al., 2011). This review concluded that exercise programs which incorporated dynamic stance balance training with a minimum of three times per week for three months duration or equal to minimum 50 hours were found to be effective in improving balance performance among older adults (Howe et al., 2011). Combinations of exercise types were found to be most common, with 43 out of the 94 intervention studies included in this review implementing a combination of more than one type of exercise to improve balance (Howe et al., 2011).

Although these reviews provide valuable information from the large number of previous randomised controlled trials identifying the effectiveness of falls prevention intervention programs (Gillespie et al., 2012) and exercise interventions in improving balance performance (Howe et al., 2011), there continue to be new types or combinations of exercise being developed and investigated. For example, a recently published protocol paper reports a current randomised controlled trial investigating the effect of dual-task functional power training on reducing falls (Daly et al., 2015).

Although many different types of exercise programs aiming to reduce falls have been investigated, to date none have had a specific focus on improving turning ability, despite turning being a relatively common activity causing falls among older people (Thigpen et al., 2000). Turning is an essential component of gait, and one study reported that 20% of steps during indoor daily activities involved turning (Sedgman et al., 1994), and another study evaluating turning in four outdoor activities found that between 8-50% of steps involved turning manoeuvres (Glaister et al., 2007). These findings emphasize the importance of turning in daily ambulation. Older people with balance impairment and history of falls have been shown to have difficulties during turning (Dite & Temple, 2002b; Justine et al., 2014). In addition, a prospective study among 96 community dwelling healthy older women aged 70 years and above has reported that 11 percent of falls occurred during turning or bending (Hill et al., 1999). Compared to regular walking, falls during turning manoeuvres are eight times more likely to result in hip fracture (Cumming, 1998), and have also been found to be associated with greater risk of slip-related falls (Nagano et al., 2013). For all of these reasons, there is a need for evaluation of exercise programs that incorporate a focus on improving performance of turning ability in older people. The present thesis aims to address this important gap in the literature about the role of an exercise intervention on improving turning performance among community dwelling older adults.

2.8 Summary of literature

Falls are a common worldwide health problem among older populations, associated with serious consequences and costs for older people, their families, and the health system. While much is known about risk factors for falls and effective interventions for falls, most of this research has been conducted in developed and Western countries. However, the ageing of populations is growing substantially more quickly in a number of developing and non-Western countries, particularly a number of countries in Asia. Emerging evidence suggests that while there are many common elements of falls risk factors that appear consistent between countries and ethnicities, there also appear to be some differences that suggest a need for investigation of falls risk factors that will be relevant to developing countries, that need to be used as a basis for driving culturally appropriate falls prevention intervention studies in these countries.

The focus of this thesis is to investigate falls prevention in a developing country in Asia – that being Malaysia. In addition, direct translation of interventions from non-Asian studies to Asian countries may warrant careful consideration. In particular, there are implications for researchers, practitioners, policy and planning personnel, and research funders who may be involved in future falls prevention research in Asia. To date, there is very little data on falls risk factors among older people in Malaysia, and to date there is no published randomised controlled trials of effective falls prevention interventions overall, nor of individualised home based exercise for falls prevention interventions in the community setting in Malaysia. The studies in this thesis will provide a starting point for understanding falls risk and one form of intervention (exercise) in the Malaysian context.

CHAPTER 3

METHODS

3.0 Introduction

The purpose of this chapter is to describe in detail the overall methods used in the two studies included in this thesis. This chapter is divided into two main sections that contain details of the methods applied in Study 1 (a cross-sectional study) and Study 2 (a randomised controlled trial). Each section contains details of methodological procedures including research setting, study population, participant criteria, recruitment, measures and measurement procedures applied in these studies. The safety precautions and ethical considerations involved in both studies are also described.

The protocol for Study 2, which is a randomised controlled trial, has been registered under the Australian New Zealand Clinical Trials Registry (ACTRN12613000855729) and has been published in BMC Geriatrics (Asmidawati et al., 2014- see Appendix 1)see Appendix 1).

Both studies were carried out among community dwelling Malaysians aged 50 years and above. Approximately six percent of Malaysia's population are were reside by older adults aged 60 years and above (Department of Statistics Malaysia, [DOSM], 2013).

Malaysia's population is projected to increase from 28.6 million (2010) to 41.5 million (2040). Nevertheless, the population increase is slow with the annual population growth rate decreasing from 1.8 percent (2010) to 0.8 percent (2040). The average population growth rate decreases by 0.05 percent per year. Among the main ethnic groups, Bumiputera showed the highest percentage increase of 4.8 percentage points, from 67.3 percent (2010) to 72.1 percent (2040) (DOSM, 2013). The sex ratio in 2010 was 106 males for every 100 females and will increase to 108 in 2020 and shall remain unchanged until 2040. The sex ratio is 103 by citizen and will be sustained over the a period of 30 years (DOSM, 2015). However, females outnumbered the males quite substantially where there is 103 females for every 100 males in the age group of 60 years and over in 2010 and the ratio reached 115 females to 100 males of the same age in 2040. Malaysian males born in 2015 can expect to live for 72.5 years while females born in the same year can expect to live to an average of 77.4 years. An older men aged 60 years or over in 2010 can look forward to another 18.4 years of life, while it is 20.9 years for older women (DOSM, 2013).

The age structure of the population can be categorised into three main groups, the younger age group (0-14 years), the working age group (15-64 years) and old age (65 years and over). Malaysia is expected to experience the population ageing in 2020, when the percentage of the population aged 65 years and over reaches 7.2 s per cent. The change in population age structure of Malaysia's population is the result of fertility and mortality decline, as well as improvement in the life expectancies at birth as well as at age 60. The decline in fertility began in the late 60s and the early 70s and dropped sharply in the 1990s (Hamid, 2015). Projections by the Department of Statistics Malaysia showed that the oldest-old group is growing at a much faster pace than the other cohorts at 5% per annum compared to the 3.2% and 4.4% growth rates for the young-old and old-old sub-populations respectively. Between 2010 and 2040, the share of the young-old (60-74) group will almost double from 6.2% to 11.4% of the total population, but the proportion of the oldest old (85+) will triple from 0.4% to 1.1% (DOSM, 2013).

These studies were conducted at Hulu Langat District in the state of Selangor, one of 13 states in Malaysia. Selangor is located in the west of Peninsular Malaysia and consists of nine districts. The total Selangor population was 5,411,324 as reported by the 2010 census, which makes Selangor one of the states with the highest population (DOSM, 2013) .

Hulu Langat is one of the largest district located in Selangor. According to the Malaysia Population and Housing Census 2010, Hulu Langat's population has increased dramatically for the past two decades, from 177,900 in 1980 to 413,900 in 1991 and 864,451 in 2000 and 1,141,880 in 2010 (DOSM, 2011). More than half of Hulu Langat population were Malays (53%), followed by the Chinese (36%), Indians (10%) and others (1%). It encompassed a combination of urban and rural with most of the population reside in towns area which situated near to Kuala Lumpur.

STUDY 1: FALL PREVALENCE AND FALL RISK ASSESSMENT AMONG COMMUNITY DWELLING ADULTS AGED 50 YEARS AND ABOVE IN MALAYSIA: CROSS-SECTIONAL STUDY

3.1 Aims of study

The aims of this study were i) to identify the prevalence of falls in community dwelling older Malaysians, and associated risk factors and circumstances, ii) to identify falls risk factors associated with falls history in the preceding 12 months, iii) to determine age and gender differences on a comprehensive suite of balance, mobility and fall risk measures, and iv) to establish an abbreviated set of balance tests from a comprehensive suite in the studied population, using factor analysis.

3.2 Study design

This is a cross-sectional study using convenience sampling, with retrospective recall of falls in the past 12 months as the primary measure. A descriptive quantitative study design was applied to quantify the prevalence of falls in the previous 12 months and to identify the risk factors for falls among the studied population.

3.3 Study population

The population for this study were community dwelling adults aged 50 years or above. The age of 50 years and above was applied in this study rather than 60 or 65 years old that is more commonly reported in studies relating to ageing because of a lower life expectancy in Malaysia compared to in Western countries. Recent data shows the life expectancy for Malaysia was 72.5 and 77.2 years for males and females respectively (DOSM, 2011).

3.3.1 Participants

Participants for this study were recruited through the University of the Third Age (U3A) Malaysia, hosted at the Institute of Gerontology, Universiti Putra Malaysia. University of the Third Age Malaysia (U3A Malaysia) is a program that provides lifelong education for adults aged 50 years and above. It is driven on the philosophy of “learning for leisure”. Based on the 2012 U3A registration record, initially there were about 280 people registered as U3A Malaysia members. Participant recruitment and the procedures of sample selection are detailed in Figure 3.1. Recruitment processes were carried out through distribution of project fliers (Appendix 2) and posters among U3A's members (Appendix 3). Eligible participants were given a brief description of the study by the Ph.D investigator during U3A's Open Day. Participants who expressed interest and/or volunteered to participate in the project were invited to the Gerontology Laboratory of the Institute of Gerontology, where detailed information about the study was provided (Appendix 4) and written informed consent was obtained (Appendix 5).

Participants were eligible for inclusion in the study if they satisfied all the following criteria:

i) aged 50 years and above
ii) community dwelling
iii) community ambulant (i.e. able to walk outdoors independently or with no more than a single point stick for support)
iv) cognitively intact [had score ≥5 on the 10 item Elderly Cognitive Assesment Questionnaire (ECAQ), (Kua & Ko, 1992)
v) had no major neurological problem (e.g stroke with unilateral or bilateral paresis, multiple sclerosis) or serious orthopaedic condition that would limit functional mobility

Exclusion criteria were aged below 50 years, institutionalised, not able to walk independently, had ECAQ score less than 5 and / or had a major neurological problem that limited their functional mobility.

This study involved laboratory measurement of balance using the Neurocom™ Balance Master, which was located at the Gerontology Laboratory, Institute of Gerontology, Universiti Putra Malaysia. Therefore, only those who were willing and able to attend the laboratory assessment were recruited.

3.3.2 Sample size

The sample size for this study was derived based on an Australian study (Nolan et al., 2010) using some similar measures and age grouping, as there were no data

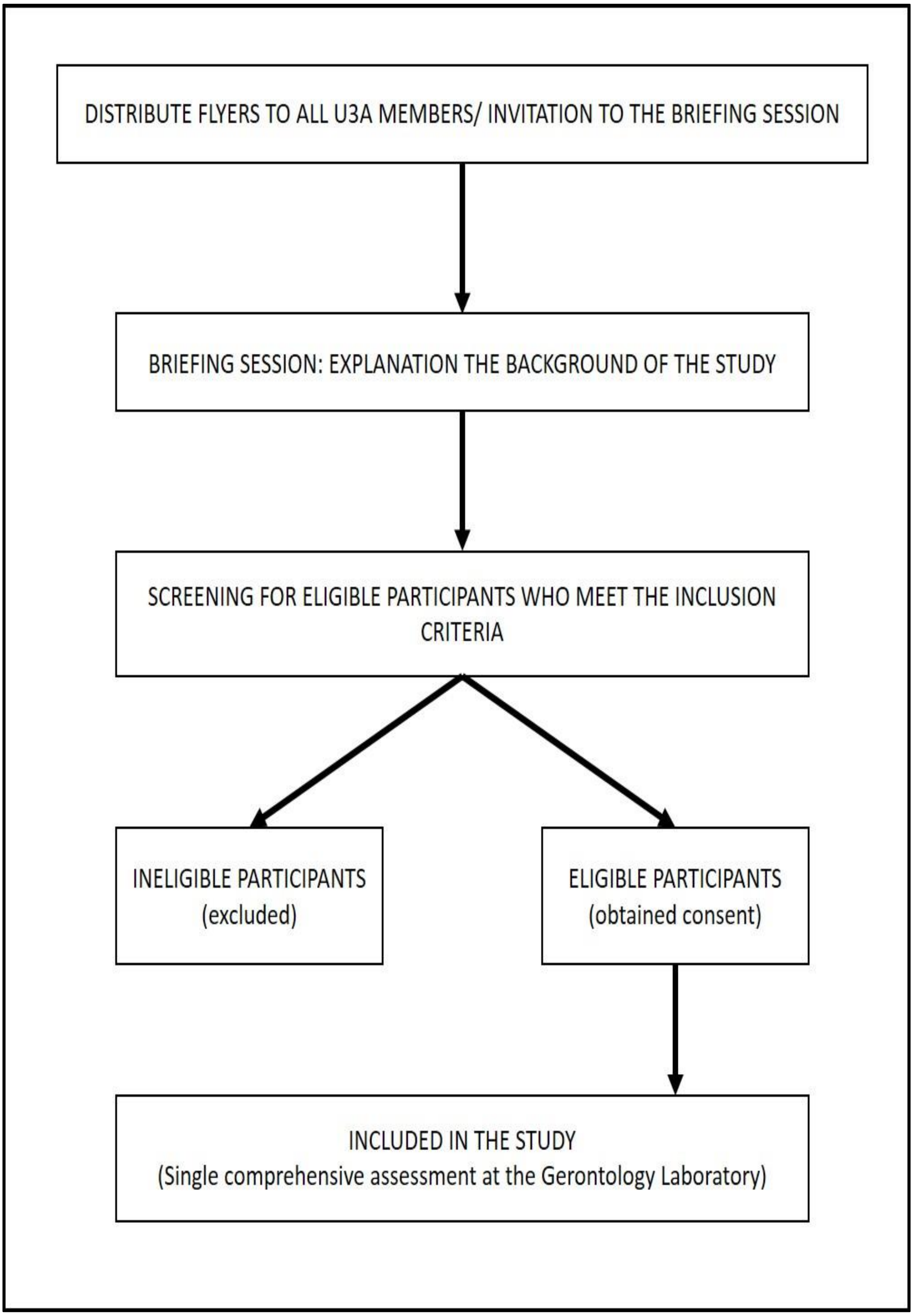


Figure 3.1. Participant flow chart for the cross-sectional study.

available using these measures in Malaysian samples. This study investigated age related changes on a number of clinical measures of balance and identified significant differences on balance measures such as the Functional Reach test between the three age groups of interest in the current study (50-59, 60-69, and 70+) for a single gender (male), using a sample size of 20-22 / age group.

Therefore, for the current study we aimed to recruit a minimum of 22 participants in each age group and gender (minimum of 132 participants overall). For the factor analysis 12 measures were planned to be included, therefore a minimum of 120 participants (at least ten participants for each variable) was included to ensure sufficient sample size for these analyses (Munro, 2004). Similarly, this sample size was adequate for the planned logistic regression analyses to determine risk factors associated with falls status (10 participants per variable) (Munro, 2004).

3.4 Measures and measurement procedures

All assessments were carried out at the Gerontology Laboratory, at the Institute of Gerontology, Universiti Putra Malaysia. Participants were assessed based on a structured evaluation comprised of four main sections: i) socio-demographic information, ii) physical and medical conditions, iii) history of falls and falls risk assessment, and, iv) clinical and laboratory assessment of balance and mobility performance. The details and procedures of each measure are detailed in the section below. The list of measures used for this study, and the subsequent randomised controlled trial (Study 2) (as many of the measures used were similar) are summarised in Table 3.1. Measures and assessment of balance and mobility applied in this study have been adapted from previous similar studies by Bock and Beurskens (2010) and Yang et al. (2012).

A structured self-administered and pre-coded questionnaire consisting of items relating to the prevalence and risk factors for falls among community dwelling older persons was used in this study (Appendix 6). Participants were required to tick an appropriate answer. Questionnaires were translated into the Malay language by a professional qualified translator, as the Malay language was the most commonly used language among Malaysians. Dual language (Malay and English) has been used for the questionnaires of this study for the non-English speaking participants. Back to back translation was done to ensure the content of the questionnaire and that

Table 3.1: Summary of the screening and assessment measures used in Study 1 (Cross-sectional) and Study 2 (Randomised Controlled Trial).

Type of Study	Study 1	Study 2	
Assessment	One-time assessment	Baseline	16 weeks follow-up
- Socio-demographic information	✓	✓	✓
- Health conditions and medication use	✓	✓	✓
- History of falls	✓ (past 12 months)	✓ (past 12 months)	✓ phone call follow up (preceding 3 weeks recorded in falls diary) and at 16 weeks
Assessment – questionnaires			
- Falls efficacy – Fall Efficacy Scale International (FES-I) 7 items	✓	✓	✓
- Depression – Geriatric Depression Scale (GDS) 15 items	✓	✓	✓
- Visual contrast sensitivity- Melbourne Edge Test (MET)	✓	✓	✓
- Activity level -Human Activity Profile-94 items (HAP)	✓	✓	✓
- Falls risk assessment - Fall Risk for Older People in the Community (FROP-Com) tool	✓	✓	✓
- Exercise adherence recorded daily in exercise diary			✓ Applicable for intervention group only
Clinical measures of balance and mobility			
- Timed Up and Go (TUG)	✓	✓	✓
- Timed Up and Go (TUG) dual task	✓	✓	✓
- Step Test (ST)	✓	✓	✓
- Functional Reach (FR)	✓	✓	✓
- Five Times Sit to Stand (FTSTS)	✓	✓	✓
Laboratory measures of balance using Neurocom™ Balance Master long force platform			
- Modified Clinical Test of Sensory Interaction of Balance (mCTSIB)	✓	✓	✓
- Limits of Stability (LOS)	✓	✓	✓
- Sit to stand test (STS)	✓	✓	✓
- Walk across (WA)	✓	✓	✓
- Step quick turn (SQT)	✓	✓	✓

individual questions would be retained correctly as in the English version. The questionnaire components of the assessment were interspersed between the physical performance tests. Participants were allowed to have a rest between the tests if required. The time taken to complete the questionnaires and clinical and laboratory assessments was approximately 90 to 120 minutes.

Due to the mixed cultural background of participants, verbal instructions were given either in Malay or English, depending on the participant's preferred language. However, to maintain consistency in the assessment, a bilingual assessment manual was developed. The translation of the assessment manual was undertaken by a qualified translator and was then verified by the researcher. The assessor (PhD candidate) was trained on the assessment procedures by her primary supervisor (an experienced physiotherapy clinician and researcher), based on procedures in the assessment manual developed prior to the study. The Assessor has been assisted by one research assistant who is trained in physiotherapy.

The details of the assessment procedures and instrumentation applied in this study are detailed below:

3.4.1 Measures of cognitive impairment

The Elderly Cognitive Assessment Questionnaire (ECAQ) (Kua & Ko, 1992) is an instrument for screening cognitive status in older people that is widely used in research in developing countries. This tool is derived from items in the Mini Mental State Examination (MMSE) and Geriatric Mental State Schedule (Kua & Ko, 1992). It has been used as a screening tool for early diagnosis of dementia. The ECAQ questionnaire consists of 10 items that are divided into sub-scales, namely: memory, orientation and information, and memory recall. The ECAQ was reported to have 85.3% sensitivity, 91.5% specificity, positive predictive value 82.8% and overall miscalculation rate 10.5% related to Kahn's Mental Status Examination for outpatient psychiatric older adults (Kua & Ko, 1992) and internal reliability Cronbach's Alpha was 0.73 (Kua & Ko, 1992). Furthermore, the ECAQ has become a recommended scale to quantify cognitive impairment objectively, less time consuming (3 to 5 minutes to administer) and is considered as an appropriate tool for cognitive screening among older people in developing countries. In the present study, participants were excluded from the study if their ECAQ score was less than 5, as recommended by Kua and Ko (1992), indicating cognitive impairment.

3.4.2 Measures of balance and mobility performance

In both studies for this thesis, balance was defined as the individual's ability to control the body's centre of mass (COM) during static or dynamic conditions with respect of the base of support (BOS) (Hudson, 1996). Mobility is defined as the individual's ability to move independently and safely from one place to another place (Rose & Hernandez, 2010; Shumway-Cook et al., 2000). In the present thesis, two broad forms of measurements were conducted to assess balance and mobility performance: i) clinical measures, and ii) assessment measures using the computerised Neurocom™ Balance Master long force platform (Bock & Beurskens, 2010; Suttanon et al., 2012; Yang et al., 2012).

3.4.2.1 Clinical measures of balance and mobility performance

Clinical measures of balance and mobility which were used in this study were selected to provide simple and quick assessment of balance performance, that incorporated key domains of balance, and that are routinely used in clinical practice and research. The selected clinical measures were: i) Timed Up and Go Test (TUG) (Podsiadlo & Richardson, 1991), ii) TUG with dual task (Shumway-Cook et al., 2000), iii) the Functional Reach Test (FRT) (Duncan et al., 1990), iv) the Step Test (ST) (Hill et al., 1996), and v) Five Times Sit To Stand Test (FTSTS) (Whitney et al., 2005). These are described in detail below:

i) Timed Up and Go (TUG) test

In the present study, the TUG was carried out by using a chair with armrests (seat height approximately 45cm with armrest height 63cm) and a stop watch. As a precautionary step, the chair was positioned near the wall to ensure it did not move when the participant moved from sit to stand at the beginning of the test and from stand to sit at the end of the test. The participant was asked to sit comfortably on the chair with hands positioned on the armrest, back leaning on the back of the chair and feet flat on the floor. The participant was allowed to use the armrest to push up when standing from the chair. However, no physical assistance was given throughout the test. A straight line marker was taped on the floor three meters from the chair to make the participant identify the distance easily. Then, the participant was asked to stand up, walk three meters to the line at their usual speed, and return to a seated position in the chair (Hill et al., 2009). Participants were allowed to use their usual walking aid that they normally used during indoors ambulation for the test. The participant was timed starting from when the assessor said "go", and timing stopped when the participant was completely seated on their chair and the back leaned on the back of the chair. Participants were allowed to have one practice trial of the TUG before they performed the actual timed test. The test was repeated two times and the average score was used in the analyses.

The TUG was carried out based on the test reported by Podsiadlo and Richardson (1991). The TUG is a common clinical test, simple, and valid method for assessing mobility. The time taken to complete the test is strongly correlated with the level of functional mobility where the faster time indicates better mobility performance. Shumway-Cook et al. (2000) proposed the cut-off level for TUG of 13.5 seconds or longer, and achieved an overall correct prediction rate of 90% for classifying fallers; for TUG manual (performing the TUG while carrying a glass of water) the cut off of 14.5 seconds or longer was associated with a 90% correct prediction rate for classification of faller status, and for TUG cognitive (performing the TUG while counting backwards) the cut-off of 15.0 seconds or longer was associated with 87% accurate classification of being a faller, in a sample of community dwelling older people.

A meta-analysis from 21 studies among healthy elders aged 60 years and above conducted by Bohannon (2006) reported that the mean Timed Up and Go for three age groups were 8.1 (7.1-9.0) seconds for 60 to 69 year olds, 9.2 (8.2-10.2) seconds for 70 to 79 years, and 11.3 (10.0-12.7) seconds for 80 to 99 years (Bohannon, 2006).

In another meta-analysis of 12 studies that investigated the mean TUG among healthy Japanese people aged 60 years or over, using two different TUG assessment protocols (usual pace, and maximum effort or speed) reported that the mean time for TUG with maximum effort was 6.60 seconds (95% CI = 6.18–7.02 s), and at usual pace was 8.86 seconds (95% CI = 7.99–9.72 seconds) respectively (Kamide et al., 2011).

ii) Timed Up and Go test with dual task

The Timed Up and Go test with dual task (Shumway-Cook et al., 2000) was also carried out to assess The Timed Up and Go (TUG) test under dual task conditions with a secondary motor task. The time taken to complete the dual task TUG has been shown to be strongly correlated to level of mobility and activities of daily living (Shumway-Cook et al., 2000). The dual task used for the current study was for the participant to carry a 6 cm height melamine cup, filled with plain water up to marked level (1cm from the cup edge) of the cup height in one hand (Figure 3.2). Participants were asked to hold the cup starting from a seated position, stand up, walk 3 meters, and return to sit in the chair. The instruction given was *"For this test, you will perform similar movements as you did in the Timed Up and Go test, but this time I want you hold this cup in one hand while you are walking. Please ensure that you will not spill the water from the cup while you are walking. You can use whichever hand is most comfortable for you".*

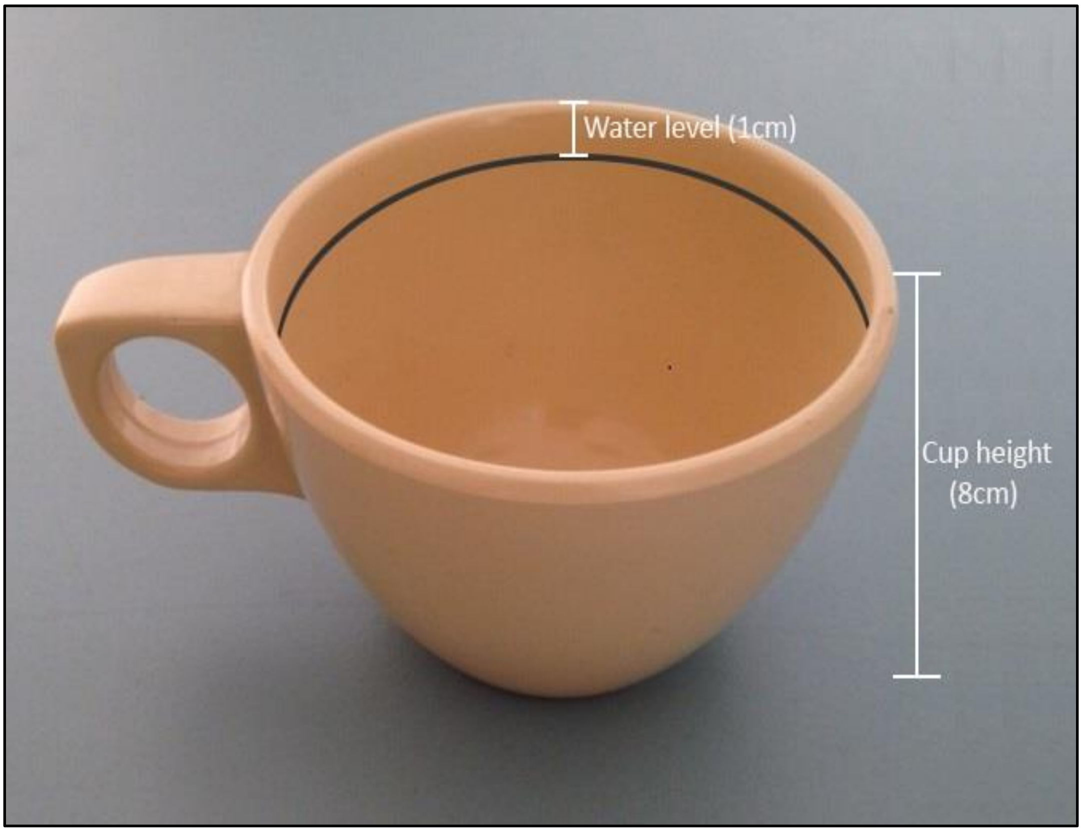


Figure 3.2. Cup used for carrying water task. Black line showed the level of water filled.

Reliability of the Timed Up and Go test single and dual task

The Timed Up and Go test was shown to have excellent intra session retest reliability in two trials in community dwelling older people (ICC > 0.98) (Shumway-Cook et al., 2000; Steffen et al., 2002). Another study by Wang et al. (2009), examined retest reliability of the Timed Up and Go test among 77 community dwelling older adults in Taiwan on two occasions (one week apart) and found that inter session reliability was excellent (ICC= 0.90). In a sample of 30 community dwelling older people, the Timed Up and Go test with dual task (carrying full cup of water) was found to have 80% sensitivity and 90% specificity to identify fall status (Shumway-Cook et al., 2000).

iii) Functional Reach test

The Functional Reach test proposed by Duncan et al. (1990) is a dynamic test of standing balance in which the performance of reaching ability in bilateral stance is assessed during self-generated perturbation. The Functional Reach (FR) is defined as the maximal distance one can reach forward beyond arm's length while maintaining a fixed base of support in the standing position (Duncan et al., 1990). The concept of this test is similar to that behind the Limits of Stability test on a force platform. However, the Functional Reach test only measures stability in the forwards reach direction.

For the present study, participants were asked to stand alongside a wall with a tape measure mounted at shoulder height (Figure 3.3). The participant's feet were 10 cm apart and the dominant arm raised to 90 degrees shoulder flexion with the hand in a fist position (Hill et al., 2009). The initial distance of reach was recorded. Then, the participant was asked to lean forward as far as they could without overbalancing or taking a step and /or requiring support to maintain balance. Participants were allowed to have one practice trial prior to testing, after which the average of two trials was recorded in centimetres (cm). Greater reach distance indicated better balance ability.

Reliability of the Functional Reach test

The Functional Reach Test (FRT) has been used to assess balance performance among various populations and settings such as community dwelling older adults, frail older adults, individuals with multiple sclerosis, people with neurological conditions and institutionalised older people. Langley and Mackintosh (2007) in their review on functional balance assessment of community dwelling older people reported four studies that demonstrated good to excellent reliability for the FRT (ICC=0.75-0.99).

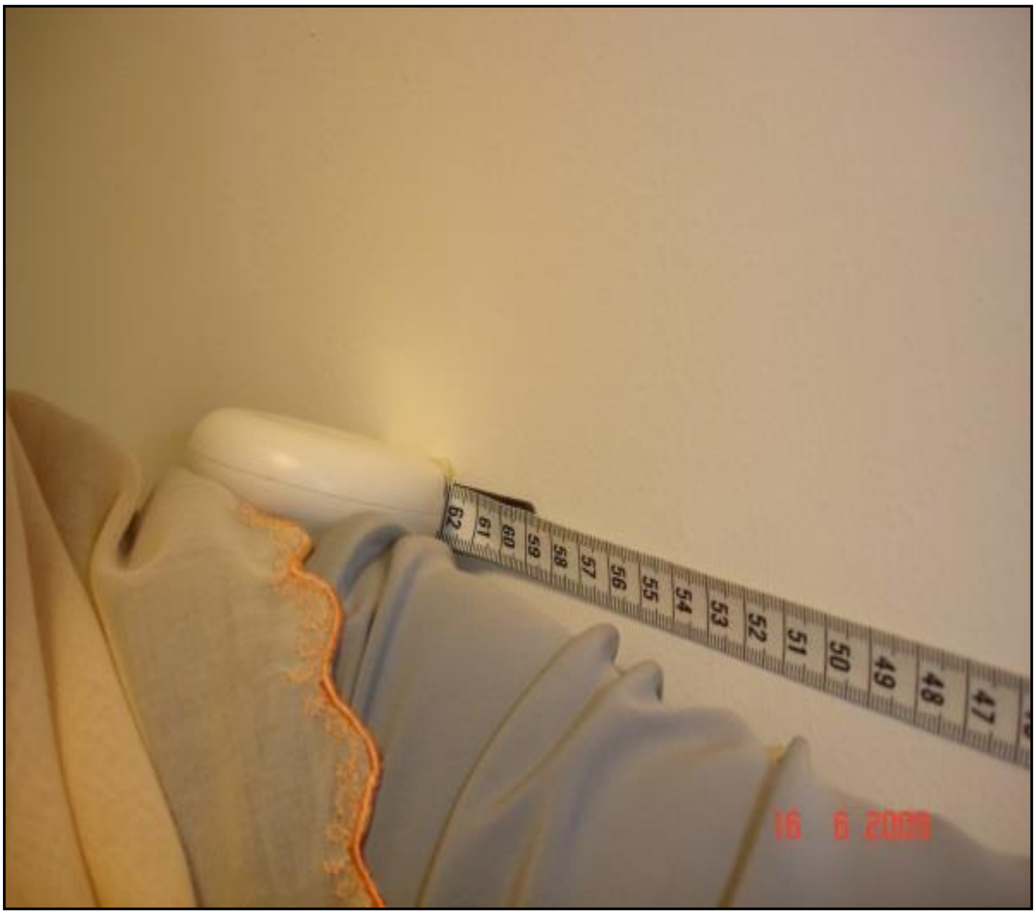


Figure 3.3. The measuring tape position for the Functional Reach Test

Another recent study reported the intra and inter-rater reliability, and the test retest reliability of the FRT in the subjects with and without hemiparesis while verifying anthropometric influences on the measurements (groups were age and gender matched) (Martins et al., 2012). The authors found that the intra-rater analysis did not show significant differences between the measures for the single, double or triple trials and there were no significant associations with anthropometric parameters for the hemiparesis and control subjects. The FRT showed excellent reliability for subjects with and without hemiparesis (ICC= 0.815) (Martins et al., 2012).

iv) Step Test (ST)

The Step Test (ST) was developed to evaluate the speed of performing a dynamic single limb stance (stepping) task (self-generated perturbation) (Hill et al., 1996). The speed of the task was calculated based on the number of times the participant can step one foot fully on then off the 7.5cm block step positioned in front of them, in 15 seconds (Figure 3.4). Each foot was tested stepping separately. At the start of the test, the participant stood unsupported in front of the step, closely supervised by the assessor. Participants were not allowed to use any walking aid or support while performing the test. If the participant required assistance to maintain balance, the test was stopped and the number of completed steps was recorded. To ensure safety, the block was placed against a wall to prevent it from moving during the test, and the test was performed near a bench top to the side to provide additional safety if the participant was at risk of overbalancing during the test.

Figure 3.4. Foot position during the Step Test.

Reliability and validity of the Step test

The Step Test (ST) measures dynamic standing balance as the result of a self-generated perturbation. The Step Test was found to have good retest reliability over a one week period in 14 community dwelling older people (ICC>0.90) and older people with stroke (ICC.93) (Hill et al., 1996). It was reported to be adequately sensitive to discriminate between fallers and non fallers in community dwelling older people (Dite & Temple, 2002b). In addition, the Step Test has been shown to have a standardized response mean of 0.92 to 0.95, which shows that it is sensitive enough to detect changes during the subacute phase of stroke rehabilitation (Bernhardt et al., 1998). A Step Test score of less than seven has also been shown to be an independent predictor of recurrent falls after stroke rehabilitation (Mackintosh et al., 2006).

Hong and colleagues (2012) reported that the Step Test is a reliable measurement tool when the number of steps is counted by either experienced or inexperienced examiners by viewing videotapes. Step Test scores with both the paretic limb and the non-paretic limb are sensitive in distinguishing subjects with chronic stroke from healthy adults older than 50 years (Hong et al., 2012).

v) Five Times Sit to Stand Test (FTSTS)

Ability to rise from a chair or bed independently is a crucial fundamental movement for normal activities of older people (Bohannon, 2011). Thus, the FTSST can be used to predict independent living in which a longer time required to complete the test indicates the likelihood of disability. The testing procedure involves participants sitting on a standard armless chair (with a seat height of 43 cm) with their arms at their sides, back upright and feet flat on the floor (Bohannon et al., 2007). The participant was then instructed to stand up with the hips and knees in full extension, and sit down five times as quickly and safely as they could without using their arms (Whitney et al., 2005). The time from the command ‘Go’ until the participant’s back touched the backrest of the chair on the fifth repetition was recorded. The average findings of two trials were used for data analyses. The mean time for normal performance of the FTSST in community dwelling older adults has been reported as 11.4 seconds for age 60-69 years, 12.6 seconds for age 70-79 years and 12.7 seconds for age 80-89 years (Bohannon et al., 2010).

Reliability of the Five Times Sit to Stand test (FTSTS)

The Five Times Sit to Stand test (FTSTS) test was found to have high retest reliability in 365 community dwellers, with an excellent intra-class correlation coefficient of ICC = 0.96 (Bohannon et al., 2007).

3.4.2.2 Laboratory measurement of balance using the Neurocom™ Balance Master

Force platform balance performance tests were undertaken on a computerised force platform (Neurocom™ Balance Master with long force platform: supplier details: Neurocom™ International Incorporated, 9570 SE Lawnfield Rd, Clackamas, OR 97015), (Figure 3.5). The Neurocom™ Balance Master long force platform uses a fixed long force platform (dimensions 152 x 46 cm) that rests on force transducers which measure the vertical forces exerted through the participant's feet. It is a computerised measurement device that provides quantitative information and feedback about stability and weight transference. This information is used in assessing and training static and dynamic balance performance in standing and in other common functions of daily living such as walking, and during sit to stand (Neurocom™ Balance Master Operator V3: Copyright©2007).

Figure 3.5. Neurocom™ Balance Master with long force platform.

All the long force platform measures were performed with shoes removed. In the first two tests (modified Clinical Test of Sensory Interaction on Balance and the Limits of Stability test), the participant stood two metres from the computer screen (Figure 3.6). For safety reasons, during the standing tests (modified Clinical Test of Sensory Interaction on Balance and the Limits of Stability test), each participant wore a safety jacket with a harness connected by two suspension straps to the overhead bar. The harness straps were tight enough to prevent the participant falling, but still loose enough to prevent the participant from gaining support and restricting the participant's movement during the tests. Ensuring correct harness strap tension was especially relevant to the Limits of Stability (LOS) test, a dynamic balance test in which maximum test response requires freedom to move. The other three tests (Walk Across, Step Quick Turn, and Sit to Stand) were performed without the overhead harness connection, as they were balance tests assessed while performing mobility tasks. However, participants were closely supervised by the assessor during these tests to ensure safety.

Figure 3.6. Participant standing barefoot on Neurocom™ Balance Master Long Force Platform.

The participant's feet were positioned according to the instructions from the Neurocom™ Balance Master long force platform Operator's manual (version 8.1) (Neurocom™ Balance Master Operator V3: Copyright© 2007), in which one of three standardised positions relating to the participant's height were used (S: short, for participant's height 76-140 cm; M: medium, for 141-165 cm; T: tall, for 166-203 cm) as shown in Figure 3.7.

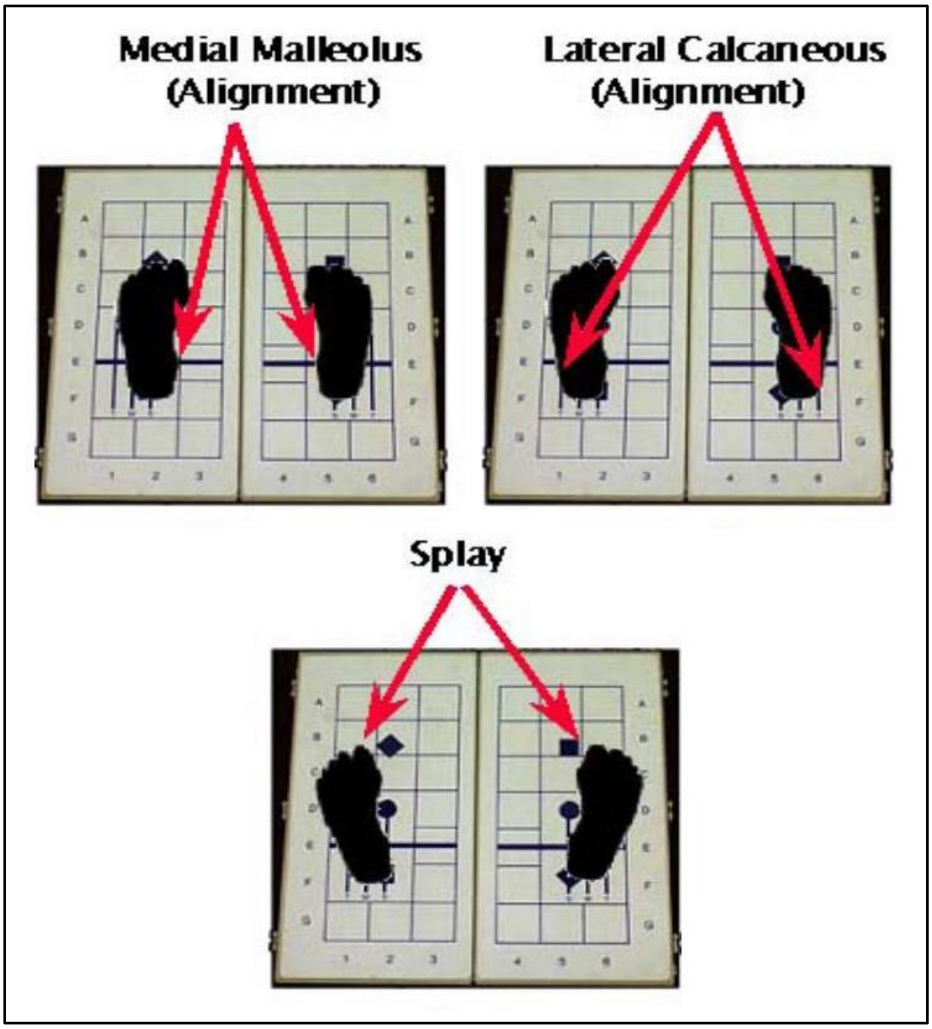


Figure 3.7. Standardised Feet Position on Neurocom™ Balance Master Long Force Platform (NeuroCom, 2008, p. 9).

Five measurements on the Neurocom™ Balance Master with long force platform were included in the studies in this thesis. They were the: (i) Modified Clinical Test of Sensory Interaction on Balance, (ii) Limits of Stability test, (iii) Walk Across, (iv) Sit to Stand test, and (v) Step Quick Turn test.

i) Modified Clinical Test of Sensory Integration on Balance (mCTSIB)

The Modified Clinical Test of Sensory Integration on Balance (mCTSIB) is a static balance test used to measure the amount of sway under four sensory conditions – eyes open and eyes closed on firm surface, and eyes open and eyes closed on foam surface as illustrated below (Figure 3.8). It was modified from the original clinical test of sensory integration developed by Shumway-Cook and Horak (1986). Buatois et al. (2008) measured the mCTSIB among community dwelling older adults, and reported that the amount of sway during the standing position with eyes closed condition was found to discriminate multiple fallers from single fallers ($p = 0.017$).

For this study, participants were asked to stand still with standard position of the feet on the force plate for 10 seconds for each trial. The feet were placed according to the instructions on the computer screen, based on the participant's height (see Section 3.4.2.2). This test was repeated three times under each test condition. During the test, participants stood bare foot. The participant was also asked to look straight ahead while standing as still as possible (to standardise visual cues in the eyes open conditions).

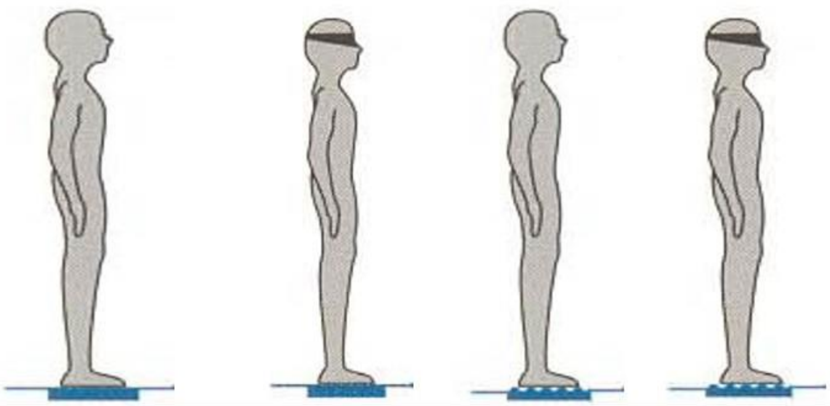
Condition	Eyes Open Firm Surface	Eyes Closed Firm Surface	Eyes Open Foam Surface	Eyes Closed Foam Surface
				
Sensory system	✓ Vision ✓ Vestibular ✓ Somatosensory	✓ Vestibular ✓ Somatosensory	✓ Vision ✓ Vestibular	✓ Vestibular

Figure 3.8. Four sensory conditions – eyes open and eyes closed on firm surface, and eyes open and eyes closed on foam surface.

The instructions for each condition were:

- Condition 1 (eyes open on firm surface) the participant was instructed *"This test will test how steady you are, so during the test, please look straight ahead and stand as still as possible until I tell you to stop. We will start when I say start".*

- Condition 2 (eyes closed on firm surface), the instruction was *"This time, I would like you stand as still as you did before but with your eyes closed. First, stand as still as possible, and when you are ready, close your eyes"* (the test was started when the participant's eyes were closed).

- Condition 3 (eyes open on foam), the participant was instructed *"Try to stand on this foam as still as possible. "This test will test how steady you are, so during the test, please look straight ahead and stand as still as possible until I tell you to stop. We will start when I say start"*.

- Condition 4 (eyes closed on foam), the participant was instructed *"This time, I would like you to stand on the foam as you did before, but with your eyes closed. It is another short test. Try to balance yourself on this foam, and when you are ready, close your eyes. Stand still and keep your eyes closed until I tell you to stop"* (the test was started when the participant's eyes were closed).

The amount of postural sway (i.e. the COG movement measured in degrees) during the trial time (10 seconds) was assessed and quantified as the COG sway velocity score (degrees/second). Smaller scores reflected less movement of the COG, and therefore, less postural instability or indicated having better balance. The participant was allowed to practice before each test. If the participant could not maintain their standing balance during testing, that trial was marked as a "Fall" and the mean Centre of Gravity (COG) sway velocity of 6 degrees/second was automatically given for the trial by the computer program.

In the study of fall risk assessment (Study 1) and secondary outcomes measures in the randomised controlled trial (Study 2) in this thesis, the composite COG sway velocity score was derived from the average of the COG sway velocity scores over the 12 trials (three trials each for four conditions) (Figure 3.9)

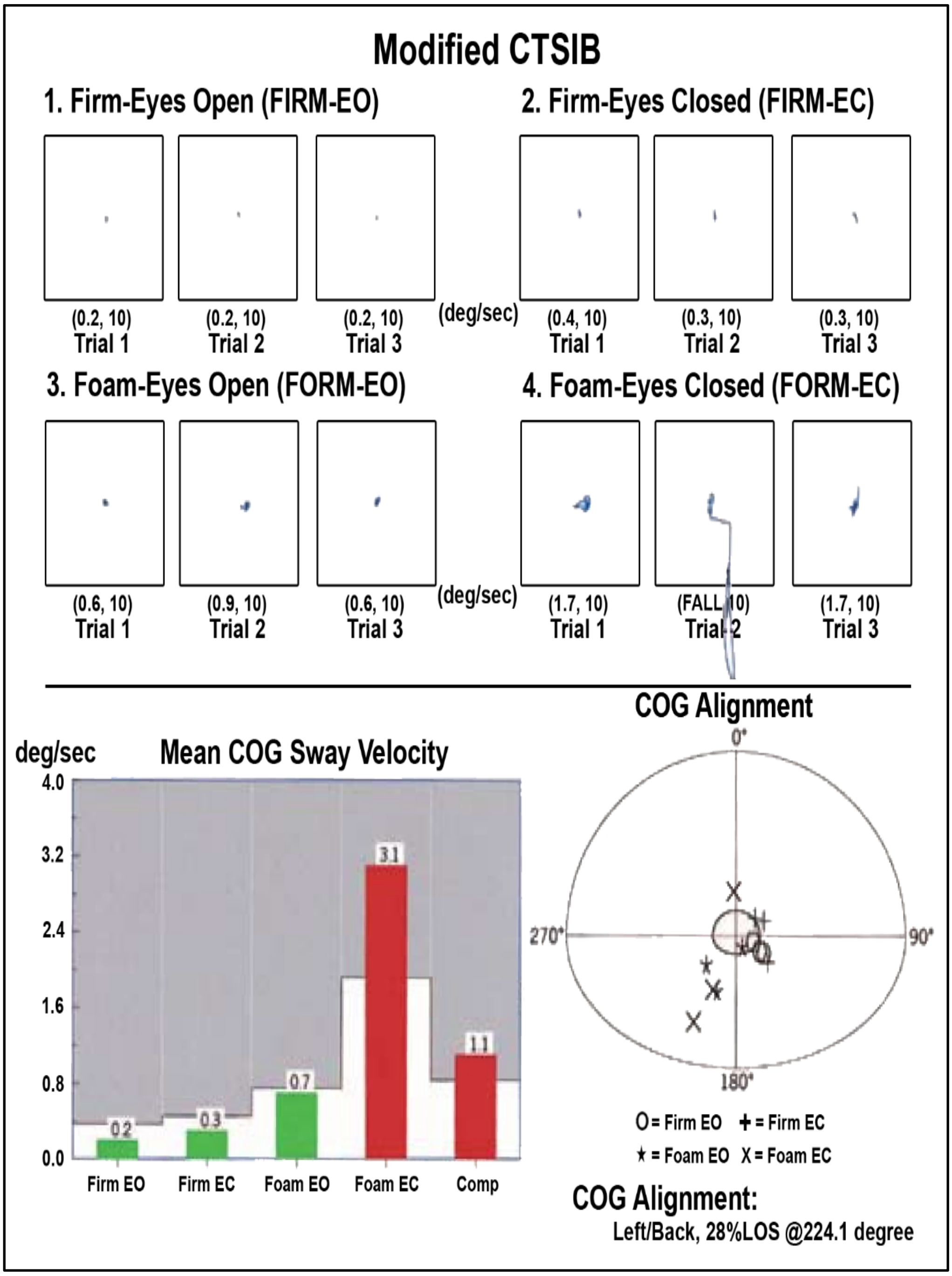


Figure 3.9. Comprehensive Report of mCTSIB on Neurocom™ Balance Master long force platform

ii) The Limits of Stability test (LOS)

The Limits of Stability (LOS) test was used to quantify the maximum distance a participant was able to intentionally displace their Centre of Gravity (COG) by shifting weight to eight targets positioned at each 45 degrees from straight ahead (in an ellipse shape), the perimeter of which related to 100% of the participant's theoretic LOS (based upon their height). The tasks were to be performed without losing balance, stepping or reaching for assistance (NeuroCom, 2008). This provides information about movement of the Centre of Gravity (COG) and postural control of a person in standing. The LOS reflects dynamic standing balance during a self-generated perturbation situation. Normal LOS is associated with normal range of motion, strength and proprioception of the lower extremities. There are eight directional (1 to 8 clockwise) targets which need to be reached by the participant, which are i) Forward (F), Forward to the right (FR), Right (R), Right Backward (RB), Backward (B), Left Backward (LB), Left (L) and Forward Left (FL). The maximum time allocated to reach the target is 8 seconds (Figure 3.10).

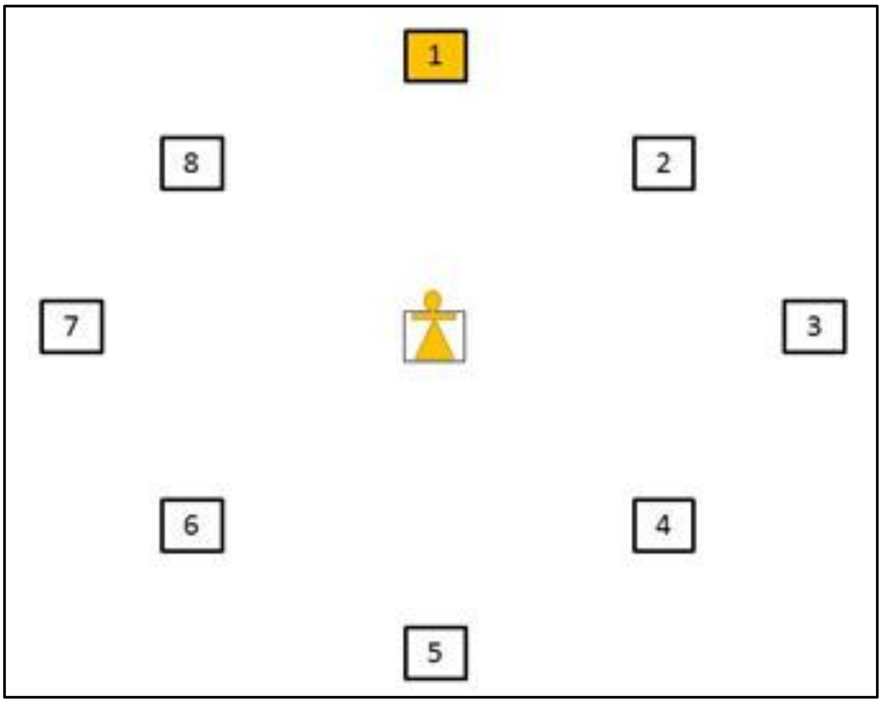


Figure 3.10. Centred box with the cursor and eight target boxes position on the Neurocom™ Balance Master's computer screen in the Limits of Stability test (LOS)

The participant stood with a standardized foot position (Figure 3.7) as recommended by the manufacturer of the equipment. A reference grid superimposed on the force plate ensured accurate placement of the feet on each testing occasion. Foot position was carefully monitored during each test and the feet were repositioned following a loss of balance or any other slight foot shift during leaning. The participant was required to lean away from the central target in the direction of each of the eight on-screen targets one at a time, without stepping or moving their feet from the standardized foot position, with their arms by the side of the body. Prior to testing, the participant was asked to view the cursor on the screen reflecting the position of their centre of pressure, and to move their weight (and therefore the cursor) in different directions.

The assessor explained and guided the movement during practice by saying "*The purpose of this test is to screen how well you can control your movement and how quickly you can respond to do this. "Now you will see the little man (cursor) on the screen. This little man is representing your body position. As you move, it will move. So you will control its movement. When I say go, you need to lean as quickly and as far as you can so that the little man (cursor) moves towards the targeted box and continue leaning (hold steady) until I tell you to stop".* Participants were asked to use an ankle strategy (demonstrated) to move toward each target. Practice was allowed prior to the beginning of the actual test for each direction.

The following parameters from the comprehensive report of Limits of Stability (as shown in Figure 3.11), representing characteristics of the COG movement towards each target were reported in this thesis:

<u>Reaction Time (RT)</u>

Reaction time is the time in seconds between the command to move and the participant's initial movement. Reaction time (RT) is considered to be an index of central nervous system functioning. It has also been reported to increase with age (Woods et al., 2015).

Movement Velocity (MVL)

Movement Velocity (MVL) is the average speed of the COG movement during the test duration, as the participant moved their centre of pressure towards the target. It is expressed in degrees /second.

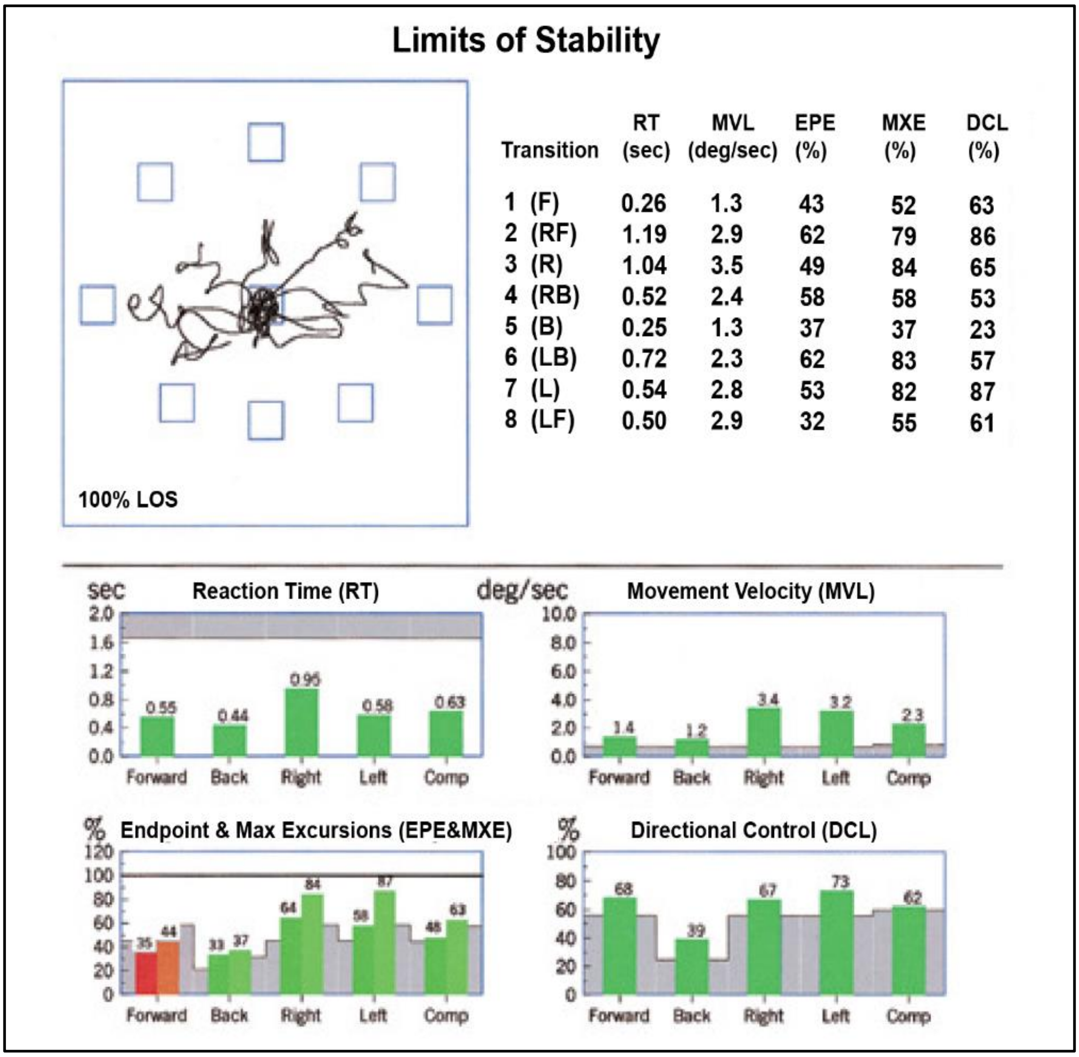


Figure 3.11. Comprehensive Report of mCTSIB on Neurocom™ Balance Master Long Force Platform.

Endpoint Excursion (EPE)

Endpoint Excursion (EPE) is the distance of the first movement towards the designated target, expressed as a percentage of maximum LOS distance. The endpoint is considered to be the point at which the initial movement toward the target ceases.

Maximum Endpoint Excursion (MXE)

Maximum Endpoint Excursion (MXE) is the maximum distance of the COG movement achieved within the trial time (8 seconds). It is expressed as a percentage of maximum limits of stability distance and can be further than the End Point Excursion (EPE) value.

Directional Control (DC)

Directional Control (DC) is a score derived from the comparison of the amount of movement in the intended direction (toward the designated target) to the amount of extraneous movement (away from the target). It is expressed as a percentage.

For the studies in this thesis, a composite score from integrating data from each of the eight target directions was assessed for each of the parameters described above, and was used in analyses.

iii) Walk Across (WA)

The Walk Across assessment is used to quantify several characteristics of gait as the participant walks at a steady state across the force plate. The participant was asked to walk at their comfortable speed across the platform, starting before the start of the force plate (wooden area) and continuing beyond the end of the force plate, which was approximately 120 cm from the end of the force platform. The test was repeated for three trials. The following gait measures were reported in this thesis as below:

Step Width

The step width is the average lateral distance between the left and the right foot on successive steps expressed in centimetres (cm).

Step Length

The Step Length is the average longitudinal distance between successive heel strikes on successive steps expressed in centimetres (cm).

Speed

Walking speed is the average velocity of forward progression expressed in centimetres per second (cm/sec). In this thesis, the average score from three trials of each measure from the Walk Across test was calculated and used in the data analyses.

iv) The Sit to Stand test (STS)

The Sit to Stand (STS) test was used to quantify several movement characteristics as the participant stood up from a seated position on the Neurocom™ Balance Master long force platform. A major component of this test included shifting the body's COG forward from an initial position over the seat to a location centred over the base of support feet, followed by extension of the body to an erect standing position while maintaining the COG position. The participant was asked to sit on a 40 cm high box placed accurately in the central square area marked on the force plate (Figure 3.12).

Figure 3.12. Sit to Stand test

Both feet of the participant were positioned equidistant from a central line. The participant was instructed to hold steady and then stand up as quickly as they can without using their arms upon the verbal cue – "GO", and to stand still at the end of the standing up manoeuvre. To ensure the participant understood the task, they were allowed to have some practice trials before the actual test. The test was repeated for three times, and the average score taken from the three trials as reported in the comprehensive report (Figure 3.13) for each measures (as described below) were used in the data analyses.

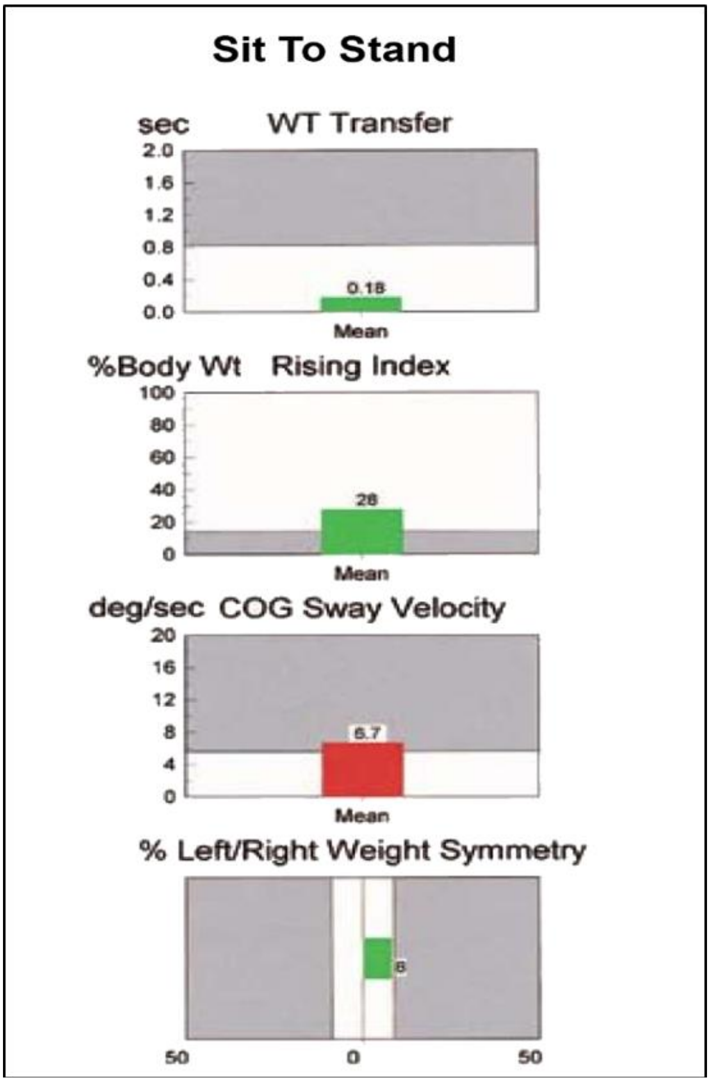


Figure 3.13. Comprehensive Report of the Sit to Stand Test (STS) on the Neurocom™ Balance Master Long Force Platform

Center of Gravity (COG) Sway Velocity

The Sway Velocity is the amount of COG sway during sit to stand and for the first 5 seconds after full standing is achieved. Sway velocity is expressed in degrees per second. Lower sway velocity during the task indicated better stability.

Rising Index

The Rising Index is the amount of force exerted by the participant's legs as they stood up from the block. The force is expressed as a percentage of the participant's body weight. Higher rising Index scores indicate better performance

v) The Step Quick Turn (SQT) test

The Step Quick Turn (SQT) test was used to quantify two movement characteristics as the participant stepped then quickly turned 180 degrees to either the right or the left direction. This test is quite challenging because balance and stepping must be tightly coordinated and head rotation during the turn produces changing visual and vestibular inputs. To turn around, the participant must anticipate the action, decelerate the forward progression of the COG, alter the stepping pattern, then, re-initiate gait in the opposite direction (Akram et al., 2010; Justine et al., 2014; Orendurff et al., 2006; Segal et al., 2008a).

A change in step pattern is also required. During this test, the participant was asked to take one step forward starting with the left leg, followed with the right leg, then to turn quickly to the left and walk back to the starting position, and to stand steady at this position. Participants were asked to do three trials of this manoeuvre. After that, participants were required to perform three trials of this manoeuvre, starting with the right leg and turning to the right (Figure 3.14).

Turn Sway

Turn sway quantifies the postural stability of the individual during the turn component of the SQT test. Turn sway is expressed as the average COG sway velocity in degrees per second. The measurement of 180 degree turn sway begins when the COG movement starts to deviate from forward progression to turning, and stops when the COG starts forward progression in the opposite direction, after completion of the 180° turn. Lower turn sway score indicates better turning performance.

Figure 3.14: Step Quick Turn Test

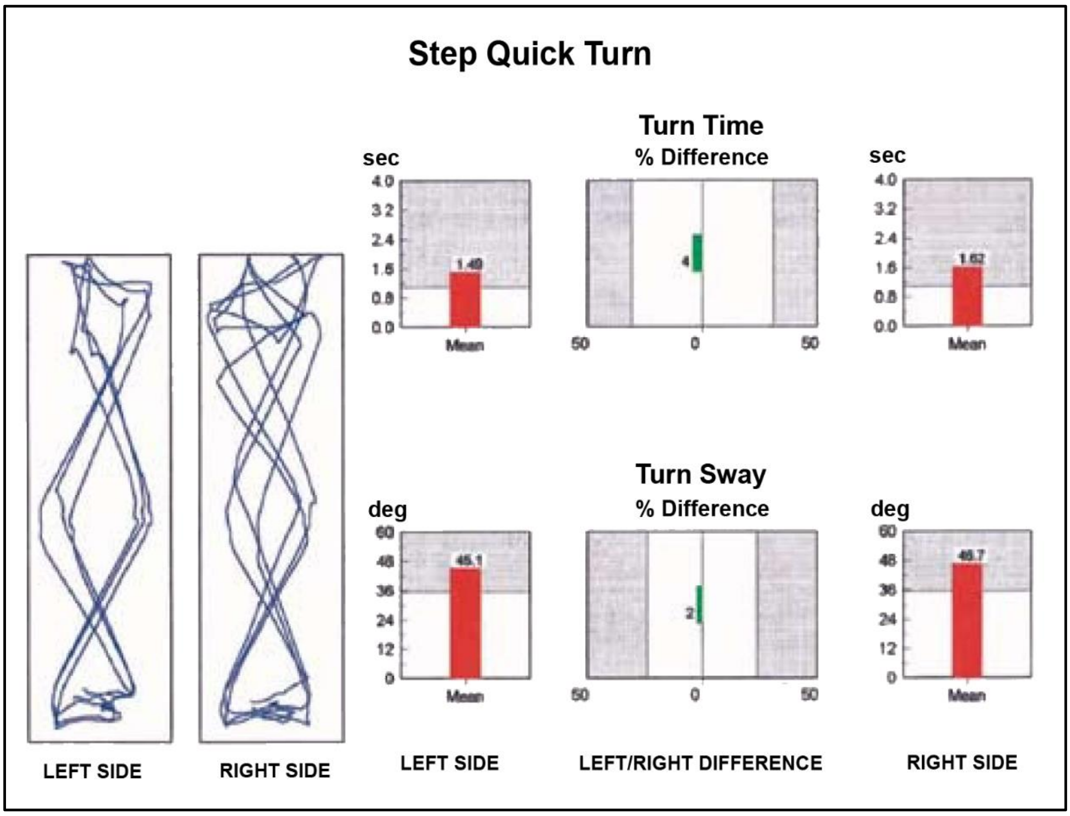


Figure 3.15: Comprehensive report of Step Quick Turn test (SQT) on the Neurocom™ Balance Master Long Force Platform

Turn Time

Turn Time quantifies the duration in seconds required for the individual to execute the 180 degree in place turn. Turn time begins when forward progression is arrested and ends when forward progression in the opposite direction is initiated. Lower turn time scores indicate better performance.

The average score for the turn measures (sway and time) for each direction were derived as reported in the comprehensive report (Figure 3.15). In this thesis, the worse score for turn sway and turn time from both turn directions was used in the data analyses (i.e.: the worst score for turning to the right and for turning to the left). This outcome measure (worst score for the two directions) has been used previously in several studies that have used the Step Quick Turn test (Hill et al., 2010; Suttanon et al., 2012).

Reliability and validity of the Neurocom™ Balance Master

The Neurocom™ Balance Master has been found to be an assessment system that is able to accurately measure postural balance and provide the physiological conditions of gait impairment and the risk of falling for most of the assessment items. The Neurocom™ Balance Master demonstrated high test-retest reliability in assessing dynamic postural stability in healthy participants (Pickerill & Harter, 2011). Previous studies conducted in various populations have investigated the retest reliability of tests performed on the Balance Master. These included tests with community dwelling older people (Clark & Rose, 2001), stroke patients (Liston & Brouwer, 1996), people with Alzheimer's disease (Suttanon et al., 2012) and traumatic brain injury populations (Newstead et al., 2005).

The five measurements of balance in this thesis performed using the Neurocom™ Balance Master were classified into two main components of balance, which are static balance and dynamic balance. The reliability established from previous studies is described accordingly for each component below.

Static balance test

The static balance test performed on Neurocom™ Balance Master long force platform involving standing conditions with altered sensory information (mCTSIB) has been investigated for retest reliability. Newstead et al. (2005) assessed the reliability for three standing conditions, namely standing with eyes open (EO), standing with eyes closed (EC), and standing with visual feedback (VF) on two occasions with a one week interval among five young adults with traumatic brain injury. This study found that reliability was moderate to high for the three conditions (standing with EC, ICC = 0.63, standing with EO, ICC = 0.84 and standing with VF, ICC = 0.95). In contrast, low to moderate retest reliability for similar standing conditions with a one week interval was reported among 20 ambulatory older people with hemiparesis post stroke (Liston & Brouwer, 1996).

In another study, Suttanon et al. (2011) examined the retest reliability of static balance under four conditions (eyes open and eyes closed on firm surface, and eyes open and eyes closed on foam) among older people with Alzheimer's disease. This study showed that retest reliability for the mCTSIB Neurocom™ Balance Master was excellent (ICC < 0.91) after a one week interval.

Dynamic balance tests

In addition, the Neurocom™ Balance Master was reported to provide high test retest reliability in assessing dynamic postural stability in healthy participants (Pickerill & Harter, 2011). This study among 23 healthy participants showed that the test-retest reliability of five LOS measures ranged from moderate to high (intra class correlation coefficient ([2,k] = 0.82 to 0.48) (Pickerill & Harter, 2011).

Naylor and Romani (2006) reported that the Step Quick Turn Test had good intra-rater reliability (ICC ≥0.70) and good inter-rater reliability (ICC ≥0.72) on three separate testing sessions with five to eight day intervals, in a group of 15 young healthy females (mean age 24.2 years) (Naylor & Romani, 2006). In another study, the Step Quick Turn test was found to be associated (r= 0.68) with the regression equation that combined age, lower extremity muscle strength and bone mineral content in predicting balance and postural instability in women aged 55 to 64 years of age (Weirich et al., 2010).

3.4.3 Measures of psychological aspects associated with falls

Two measures of the psychological aspects associated with falls in older people (depression and fall efficacy) were used in this thesis [the Geriatric Depression Scale (GDS-15) and the Short Falls Efficacy Scale (FES-I)] respectively.

3.4.3.1 Depression

Geriatric Depression Scale (GDS-15)

The level of depression was screened using the adapted tool – the Short Form Geriatric Depression Scale (GDS-15) consisting of 15 questions (Figure 3.16) (Yesavage & Sheikh, 1986). The test took approximately five to seven minutes to complete. In scoring of the 15 items, 10 items indicated the presence of depressive symptoms when answered positively, while the rest (question numbers 1, 5, 7, 11, 13) indicated "depressive" symptoms when answered negatively. Scores were divided into four categories namely normal (score range from 0 to 4), mild depression (score ranged from 5 to 8); moderate depression (score ranged from 9 to 11); and severe depression (score ranged from 12 to 15) (Greenberg, 2012).

The GDS 15 has been shown to be a reliable and valid screening tool for measuring major depression across different age, ethnicity, gender and medical conditions. Nyunt et al. (2009) have assessed the criterion validity and reliability of the GDS-15 on a large validation sample of 4253 community dwelling older Asian across different age groups, ethnicity and comorbidities. A structured interview using the DSM-IV-TR Disorders was carried out by a medical researcher trained in psychiatric assessment, who was blinded to the results of the GDS screening. The study showed that the overall Cronbach's alpha was 0.80 and intra-class coefficient of the test-retest reliability over two weeks interval was good (ICC= 0.83). GDS-15 showed a high sensitivity (0.97) and specificity (0.95) for different age groups, gender, ethnicity and different comorbidities in community dwelling older people at the cut off 4/5 (Nyunt et al., 2009). In the present study, participants were asked to indicate "yes" or "no" for each item and the sum of the items score was calculated and was used in the analyses.

3.4.3.2 Falls efficacy

Short Fall Efficacy Scale-International (FES-I)

The Short FES-I fear of falling scale which comprised seven items is a questionnaire evaluating self-report of falls efficacy (Figure 3.17) (Kempen et al., 2008), also commonly called "fear of falling".

This tool assessed the level of concern in performing activities of daily living without falling. The participant was asked to rate their concern in performing each of the seven activities. The level of concern was measured on a four point Likert Scale for each item, from 1 indicating 'not at all' to 4 indicating 'very concerned" (Kempen et al., 2008). The total score of the FES-I was calculated by summing the score for each item together, with a range from 7 (no concern about falling) to 28 (severe concern about falling). Low scores on the FES-I reflect greater balance confidence and scores > 10 in the shortened seven item FES-I indicate high concern about falling (Delbaere et al., 2006).

Geriatric Depression Scale (GDS) Short Form

Choose the best answer for how you have felt over the past week:

1. Are you basically satisfied with your life?	Yes	No
2. Have you dropped many of your activities and interests?	Yes	No
3. Do you feel that your life is empty?	Yes	No
4. Do you often get bored?	Yes	No
5. Are you in good spirits most of the time?	Yes	No
6. Are you afraid that something bad is going to happen to you?	Yes	No
7. Do you feel happy most of the time?	Yes	No
8. Do you often feel helpless?	Yes	No
9. Do you prefer to stay at home rather than going out and doing new things?	Yes	No
10. Do you feel you have more problems with memory than most?	Yes	No
11. Do you think it is wonderful to be alive now?	Yes	No
12. Do you feel pretty worthless the way you are now?	Yes	No
13. Do you feel full of energy?	Yes	No
14. Do you feel that your situation is hopeless?	Yes	No
15. Do you think that most people are better off than you are?	Yes	No

Figure 3.16: The Short Form Geriatric Depression Scale (GDS-15) consisting of 15 questions

INSTRUCTION : The participant is asked to rate their confidence in performing each of the 7 activities without falling on a 1-4 scale. Scale 4 refers to 'very concerned' in performing the task without having a fall while scale 1 refers to 'not at all concerned' in performing the task without overbalancing. To obtain a total score for the Short FES-I simply add the scores on all the items together, to give a total that will range from 7 (no concern about falling) to 28 (severe concern about falling).

No.	Type of activity	*not at all concerned*	*somewhat concerned*	*fairly concerned*	*very concerned*
1	Getting dressed or undressed	1 ☐	2 ☐	3 ☐	4 ☐
2	Taking bath or shower	1 ☐	2 ☐	3 ☐	4 ☐
3	Getting in or out of a chair	1 ☐	2 ☐	3 ☐	4 ☐
4	Going up or down of a chairs	1 ☐	2 ☐	3 ☐	4 ☐
5	Reaching for something above your head or on the ground	1 ☐	2 ☐	3 ☐	4 ☐
6	Walking up or down the slope.	1 ☐	2 ☐	3 ☐	4 ☐
7	Getting out to a social event(e.g: religious service, family gathering or club meeting)	1 ☐	2 ☐	3 ☐	4 ☐
	Total scores				

Ref: Kempen GI, Yardley L, van Haastregt JC, Zijlstra GA, Beyer N, Hauer K, Todd C. The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling. Age Ageing. 2008 Jan;37(1):45-50. Epub 2007 Nov 20.

Figure 3.17: Short falls efficacy scale International (FES-I)

In a study among older people aged 70 years and above the short version FES-I was shown to have excellent test-retest reliability (ICC =0.83) and was comparable to the full FES-I (Kempen et al., 2008). In addition, the FES-I has been shown to have acceptable reliability and construct validity across different samples in various countries. Furthermore, the shortened seven item-FES-I has been recommended as a measurement tool for falls efficacy that can be utilised in different samples in various countries (Delbaere et al., 2010).

3.4.4 Measures of falls and falls risk

3.4.4.1 History of falls

In the present study, a fall was defined as "an unexpected event which results in a person coming to rest advertently on the ground or other lower level, other than as a consequence of sustaining a violent blow, loss of consciousness or sudden onset of paralysis as a stroke or epileptic seizure" (Gibson et al., 1987, p. 4). The number of falls that a participant had experienced in the 12 months preceding their first assessment was retrospectively reported by participants. Falls measures included in Study 1 were: i) number of falls, ii) location of falls, iii) cause of fall, iv) type and severity of injuries, and v) time of fall.

3.4.4.2 Risk of falls

The Falls Risk for Older People in the Community (FROP-Com) tool (Russell et al., 2008) is a detailed assessment of 13 falls risk factors (Figure 3.18). Each domain of the assessment describes evidence based falls risk factors among community dwelling older adults, and each domain is scored to reflect graded risk [most items are scored as nil (0), mild (1), moderate (2), or severe (3)]. The FROP-Com has been shown to have good retest reliability (ICC for intra-rater and inter-rater reliability were 0.93 and 0.81 respectively), and moderate accuracy predicting falls (sensitivity 71% and specificity 56%) (Russell et al., 2008). A total score between 0 and 60 is obtained, where higher scores indicate greater level of risk of falling. Then, the total score was categorised into three fall risk grading levels, namely (i) mild fall risk, (0-11), (ii) moderate fall risk (12-18), and (iii) high fall risk (19-60).

NARI
NATIONAL AGEING RESEARCH INSTITUTE LTD
Bringing research to life

Falls Risk for Older People– Community setting (FROPCom)

Personal details

Name: ______________________

Personal Code #:

Date of Assessment: / /

Address: ______________________________________

DOB: ____________________ Telephone: ____________________

Marital Status:
Single / Married (defacto) / Widowed / Divorced (separated) / Unknown (circle)

Usual living arrangements: ____________ ____________

Recent health / community services use:

1. Community Aged Care Packages/Services	Y/N	2. Community Rehabilitation................	Y/N
3. Doctors Appointment	Y/N	4. Doctor Home Visit	Y/N
5. Home Help	Y/N	6. Home Modifications	Y/N
7. Home Rehabilitation	Y/N	8. Linkages Package...........................	Y/N
9. Meals on Wheels	Y/N	10. OT Home visit................................	Y/N
11. Outpatient Appointment..	Y/N	12. Other...	Y/N
13. Post Acute Care..	Y/N	14. Personal Care	Y/N
15. Respite Care	Y/N	16. District Nursing Services	Y/N
17. Physiotherapist Appointment	Y/N	18. Dietician	Y/N
19. Podiatrist	Y/N	20. Personal Alarm	Y/N
21. Day Centre	Y/N	22. Falls and Balance clinic	Y/N

Comments...
....

• Is English the individuals preferred language? If not, what is?	☐ Yes	☐ No
• Does the individual have functional English?	☐ Yes	☐ No

History of falls (0-3points)		SCORE
1. Number of falls in the past 12 months?	☐ No falls (0) ☐ 1 fall (1) ☐ 2 falls (2) ☐ 3 or more (3)	[ ]
2. Was an injury sustained in any of the fall/s in the past 12 months? *(rate most severe injury due to a fall in the past 12 months)*	☐ No (0) ☐ Minor injury, did not require medical attention (1) ☐ Minor injury, did require medical attention (2) ☐ Severe injury (fracture, etc) (3)	[ ]

Figure 3.18: Falls Risk for Older People in the Community (FROP-Com)

3. Describe the circumstances of the most recent fall in the past 12 months. **Time of fall**: AM / PM *(please circle)* **Location of fall**: inside home / outside home / community **Direction of fall**: left / right / forward / backward / down / can't remember / other **Cause of fall**: trip / slip / loss of balance / knees gave way / fainted / feeling dizzy or giddy / alcohol or meds / fell out of bed / unknown Comments: **Injuries:**	
Sub total for this page	[ ]

***Medications** (0-3 points)*		
4. List all medications currently taken.	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
5. Number of prescription medications.	☐ No medication (0) ☐ 1–2 medications (1) ☐ 3 medications (2) ☐ 4 or more medications (3)	[ ]
6. Does the individual take any of the following type of medication? ☐ sedative ☐ antidepressant ☐ anti-epileptics ☐ central acting analgesic ☐ digoxin ☐ diuretics ☐ type 1a antiarrythmic ☐ vestibular suppressant	☐ None apply (0) ☐ 1–2 apply (1) ☐ 3 apply (2) ☐ 4 or more apply (3)	[ ]
***Medical conditions** (0-3 points)*		
7. Does the individual have a chronic medical condition/s affecting their balance & mobility? ☐ Arthritis ☐ Respiratory condition ☐ Parkinson's Disease ☐ Diabetes ☐ Dementia ☐ Peripheral neuropathy ☐ Cardiac condition ☐ Stroke ☐ Other neurological conditions ☐ Lower Limb Amputation. ☐ Osteoporosis ☐ Vestibular Disorder ☐ Other dizziness ☐ Back pain ☐ lower limb joint replacement	☐ None apply (0) ☐ 1-2 apply (1) ☐ 3-4 apply (2) ☐ 5 or more apply (3) Osteoporosis: ☐ Unknown ☐ does not have	[ ]
Sensory loss		

Figure 3.18: (continued)

8. Does the client have an uncorrected sensory deficit/s that limits their functional ability?	Vision: ☐ no (0) ☐ yes (1) Somato Sensory: ☐ no (0) ☐ yes (1)	[ ]
Feet & footwear		
9. Does the client have foot problems, e.g. corns, bunions, swelling etc.	☐ no (0) ☐ yes (1) (specify):	[ ]
10. Does the client have inappropriate, poorly fitting or worn footwear?	☐ no (0) ☐ yes (1) (specify):	[ ]
***Cognitive status**: (score 0-3 points).*		
11. AMTS score ☐ Age ☐ Time to the nearest hour ☐ Address to recall – 42 West St ☐ Current year ☐ Current location (where are we?) ☐ Recognition of two persons (Dr, nurse) ☐ Date of birth ☐ Years of first World War ☐ Name of current prime minister ☐ Count backwards from 20 by ones ☐	Number of correct responses: ☐ 9-10 (0 point) ☐ 7-8 (1 point) ☐ 5-6 (2 points) ☐ 4 or less (3 points) Score: ..../ 10	[ ]
Continence:		
12. Is the individual continent?	☐ Yes (0) ☐ No (1)	[ ]
13. Does the individual regularly have to go to the toilet in the night (3 or more times)?	☐ No (0) ☐ Yes (1) (if uses a bottle, rate as 0)	[ ]
	Sub total for this page	[ ]

***Nutritional status** (score 0-3 points)*		
14. Has the individual's food intake declined in the past three months due to a loss of appetite, digestive problems, chewing or swallowing difficulties?	☐ No (0) ☐ Small change, but intake remains good (1) ☐ Moderate loss of appetite (2) ☐ Severe loss of appetite / poor oral intake (3)	[ ]
15. Weight loss during the last 3-12 months.	☐ Nil (0) ☐ Minimal (<1 kg) or unsure (1) ☐ Moderate (1-3kg) (2) ☐ Marked (>3kg) (3)	[ ]
16. Number of alcoholic drinks consumed in the past week	☐ Nil (0) ☐ 1-3 (1) ☐ 4-10 (2) ☐ 11+ (3)	[ ]

Figure 3.18: (continued)

Environment *(score 0-3 points)*		
17. Did the home environment appear safe? *(NOTE: only rate if undertaking a home visit assessment, leave blank otherwise)*	☐ Yes (0) ☐ Minimal environmental hazards (1) ☐ Moderate environmental hazards requiring modification (2) ☐ Extremely unsafe environment (3)	[ ]
Functional Behaviour *(score 0 –3 points)*		
18. Observed behaviours in Activities of Daily Living and Mobility indicate	☐ Consistently aware of current abilities /seeks appropriate assistance as required (0) ☐ Generally aware of current abilities /occasional risk-taking behaviour (1) ☐ Under-estimates abilities / inappropriately fearful of activity (2) ☐ Over-estimates abilities/frequent risk-taking behaviour (3)	[ ]
Function *(score 0-3 points)*		
19. Prior to this fall, how much assistance was the individual requiring for personal care activities of daily living (eg dressing, grooming, toileting)? *(NOTE: If no fall in last 12 months, rate current function)*	☐ none (completely independent) (0) ☐ supervision (1) ☐ some assistance required (2) ☐ completely dependent (3)	[ ]
20. Has this changed since the most recent fall? *(leave blank if no falls in 12 months)*	☐ No (0) ☐ Yes (1) (specify):	[ ]
21. *Prior to this fall, how much assistance was the individual requiring for instrumental activities of daily living (eg shopping, housework, laundry)? (NOTE: If no fall in last 12 months, rate current function)*	☐ none (completely independent) (0) ☐ supervision (1) ☐ some assistance required (2) ☐ completely dependent (3)	[ ]
22. Has this changed since the most recent fall? *(leave blank if no falls in 12 months)*	☐ No (0) ☐ Yes (1) (specify):	[ ]
	Sub total for this page	[ ]

Figure 3.18: (continued)

Balance *(score 0-3 points)*		
23. Does the individual, upon observation of walking and turning, appear unsteady or at risk of losing their balance? *(NOTE: Rate with usual walking aid. Tick one only, if level fluctuates, tick the most unsteady rating)*	o No unsteadiness observed (0) o Yes, minimally unsteady on walking or turning (1) o Yes, moderately unsteady on walking or turning (needs supervision) (2) o Yes, consistently and severely unsteady on walking or turning (needs constant hands on assistance (3)	[ ]
Gait / Physical Activity *(score 0-3 points)*		
24. Can the individual walk safely around their own home?	o Independent, no gait aid needed (0) o Independent with a gait aid (1) o Safe with supervision / physical assistance (2) o Unsafe (3)	[ ]
25. Can the individual walk safely in the community?	o Independent, no gait aid needed (0) o Independent with a gait aid (1) o Safe with supervision / physical assistance (2) o Unsafe (3)	[ ]
26. If a walking aid is used, list the aid and when it is used.	Aid............................ o indoors o outdoors Comments:	
27. How physically active is the individual?	o Very active (exercises 3 times per week) (0) o Moderately active (exercises less than twice per week) (1) o Not very active (rarely leaves the house) (2) o Inactive (rarely leaves one room of the house) (3)	[ ]
28. Has this changed since the most recent fall?	o No (0) o Yes (1) (specify):	[ ]
	Sub total for this page	[ ]
	Sub total for page 1	[ ]
	Sub total for page 2	[ ]
	Sub total for page 3	[ ]
	Total Risk Score	[ ]

<u>Grading of falls risk:</u>

☐ Mild falls risk	0 –11	Implement actions for identified individual risk factors, & recommend health promotion behaviour to minimise future ongoing risk (eg – increased physical activity, good nutrition)
☐ Moderate falls risk	12-18	Implement actions for identified individual risk factors
☐ High falls risk	19 - 60	Implement actions for identified individual risk factors, and implement additional actions for high falls risk (e.g. refer to a specialist Falls Clinic)

(maximum =60)

Figure 3.18: (continued)

In this thesis, the environment domain in the FROP-Com was excluded because all assessments were conducted at the Gerontology Laboratory and not at the participant's home. Therefore, the maximum score of the FROP-Com was reduced by three, instead of 60 to 57. This modification was similar to that reported in a previous study (Williams et al., 2010).

3.4.5 Measure of visual contrast sensitivity

Contrast sensitivity was assessed using the Melbourne Edge Test (Verbaken and Johnston, 1986). This test consists of a series of 20 circular patches containing edges with reducing contrast. Every circular patch was divided into two halves with the angle of contrasting shade division varying randomly between vertical, horizontal, 45 degrees to left or 45 degrees to the right (Figure 3.19). The level of contrast reduced as the participant progressed through the chart up to the point where they were not able to identify any contrast. The last numbered circular patch in which the contrast was accurately identified was recorded as the contrast sensitivity score. The maximum score of 24 indicated an excellent score, with all the contrast in the circular patches being correctly identified, while a score cut off less than 16 has been reported as poor visual contrast sensitivity (Lord et al 1991). In the present thesis, the score was divided into four categories namely accordingly "Excellent" 24, 20-23 as "Good", 16-19 as "Fair" and 1-15 as "Poor". Haymes and Chen (2004) reported a 95% confidence interval of 5.2 dB for test–retest measures on the new back-lit MET compared with 3.7 dB for the paper-based MET in 22 subjects with visual impairment. In another related study, the MET with back lit screen has been reported to have significant higher contrast sensitivity compared to the paper based MET

Participants were tested in brightly lit conditions in a seated position at a table in the assessment room. Participants were asked to sit with the visual contrast chart and light box leaning at an angle of approximately 45 degrees from the table top at a usual reading distance (about 50-60cm) from the light box, which illuminated the edge test transparency. Participants were asked to identify the contrast starting from the top row and then progressing through to the fourth row. Participants used their response card to indicate the angle of division by pointing to one of the four edge options on the response card. The instruction given was "*This test measures how well you can see edges under low contrast conditions. I want you to look at this transparency on* *the light box, but please try not to touch it. Look at the circles one at a time and tell me which way the line goes through the circle, that is, point to the correct match for each on this (response) card."*

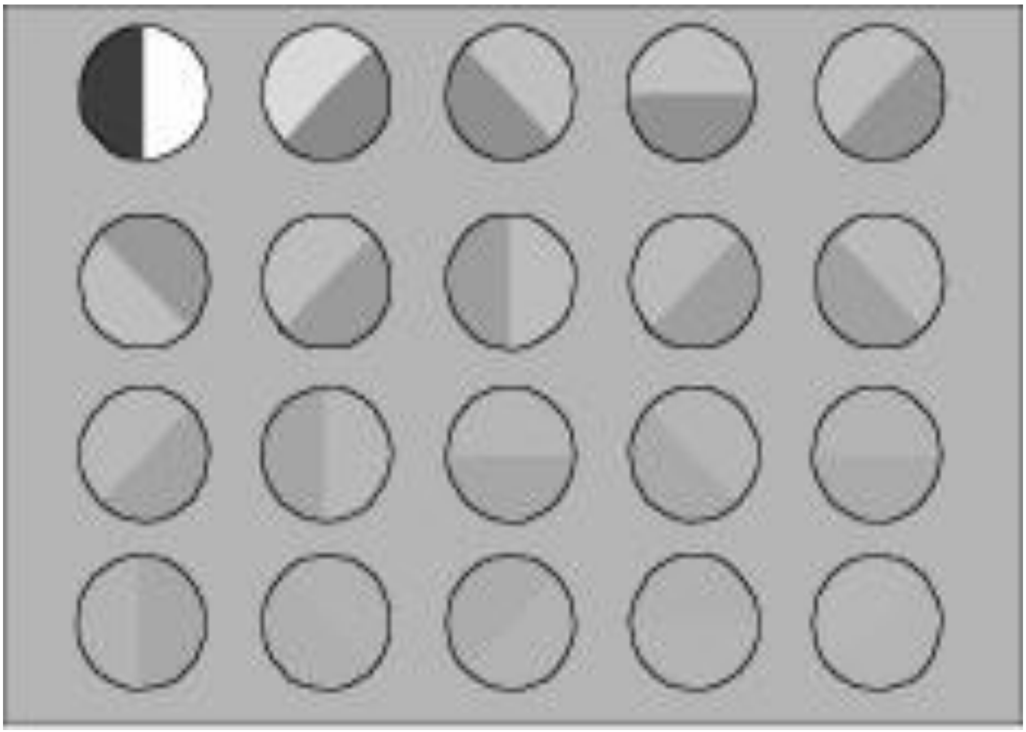


Figure 3.19: The Melbourne Edge Test chart (Verbaken & Johnston, 1986).

3.4.6 Measures of physical activity level

The Human Activity Profile (HAP) (Fix & Daughton, 1988) is a questionnaire used to measure physical activity level (Figure 3.20). The HAP has been used to evaluate physical activity in a wide variety of clinical populations as well as in healthy older people. It consists of 94 items that originally were derived from the 105 item Additive Daily Activities Profile Test (ADAPT). The HAP is used to assess a variety of activities ranging from activities of daily living and instrumental activities of daily living to recreational and sport activities. The list of activities has been ranked in order of the energy expenditure required to perform the task. As the HAP contains a list of activities from very easy to very strenuous, it is unlikely to have a ceiling effect when measured in community dwelling older people (Davidson & de Morton, 2007). Each activity is based on estimated metabolic equivalents (METs), with each successive question representing a slightly higher MET level. The lowest level of activity is getting in and out of bed (a score of 1) and the most difficult activity is running or jogging 3 miles (approximately 5km) in 30 minutes or less (a score of 94).

The HAP has been found to have moderate to strong correlation with the physical functioning scale of the SF-36 and physical performance measures in a population of adults undergoing hemodialysis (Johansen et al., 2001), arthritis (Bilek et al., 2005), a population of adults with knee osteoarthritis (Bennell et al., 2004), as well as measures of physical function using an accelerometer among elderly women (Bastone et al., 2014).

In the present thesis, participants were asked to indicate for each of the 94 activities whether they are *"Still doing this activity"* (if they completed the activity independently the last time they had the need or opportunity to do so), or *"Have stopped doing"* (if they engaged in the activity in the past, but would not be able to perform the activity currently if they had the need or they had opportunity to do so) or '*Never did this activity'* (if they have never engaged in the specific activity), based on the participant's self-report. Two scores were obtained from the questionnaire: The Maximum Activity Score (MAS) and the Adjusted Activity Score (AAS). The Maximum Activity Score is the number of the most strenuous, highest numbered task the participant reported they were still doing. The Adjusted Activity Score was calculated by subtracting from the Maximum Activity Score the number of activities with lower values which the participant rated as "stopped doing". The Maximum Activity Score and Adjusted Activity Score (AAS) had possible range of 0-94, with lower scores indicating lower level of physical activity. For the studies in this thesis, the Adjusted Activity Score was used in the analyses.

Davidson and de Morton (2007) in their systematic review summarised 39 studies among various populations including community dwelling healthy older people and a wide variety of clinical populations. Results revealed that the correlation coefficient for test retest reliability ranged from 0.76 to 0.97 for the Maximum Activity Score and 0.79 to 0.97 for the Adjusted Activity Score (Davidson & de Morton, 2007). Bennell et al. (2004), reported test retest reliability was excellent (ICC=0.96) among people with knee osteoarthritis. Furthermore, the minimal change in score at 90% confidence (MDC_{90}) where change is beyond measurement error was estimated to be 7.8 for the Maximum Activity Score and 6.8 for the Adjusted Activity Score respectively (Davidson & de Morton, 2007).

Human Activity Profile

HAPMAS = …………… HAPAAS = ……………

	Still doing this activity	*Have stopped doing the activity*	*Never did this activity*
1. Getting in and out of chairs or bed (without assistance)			
2. Listening to the radio			
3. Reading books, magazines, or newspapers			
4. Writing (letters, notes)			
5. Working at a desk or table			
6. Standing (for more than one minute)			
7. Standing (for more than five minutes)			
8. Dressing or undressing (without assistance)			
9. Getting clothes from drawers or closets			
10. Getting in and out of a car (without assistance)			
11. Dining at a restaurant			
12. Playing cards/table games			
13. Taking a bath (no assistance needed)			
14. Putting of shoes, stockings or socks (no rest or break needed)			
15. Attending a movie, play, church event, or sports activity			
16. Walking 30 yards (27 metres)			
17. Walking 30 yards (non stop)			
18. Dressing/undressing (no rest or break required)			
19. Using public transport or driving a car (99 miles or less)			
20. Using public transport or driving a car (100 miles or more)			
21. Cooking your own meals			
22. Washing or drying dishes			
23. Putting groceries on shelves			
24. Ironing or folding clothes			
25. Dusting/polishing furniture or polishing a car			
26. Showering			
27. Climbing 6 steps			
28. Climbing 6 step (non stop)			
29. Climbing 9 step			
30. Climbing 12 steps			

Figure 3.20. The Human Activity Profile (HAP) for items 1 – 30.

	Still doing this activity	*Have stopped doing the activity*	*Never did this activity*
31. Walking ½ block on level ground			
32. Walking ½ block on level ground (non stop)			
33. Making a bed (not changing the sheets)			
34. Cleaning the windows			
35. Kneeling or squatting to do light work			
36. Carrying a light load of groceries			
37. Climbing 9 steps (non stop)			
38. Climbing 12 steps (non stop)			
39. Walking ½ block uphill			
40. Walking ½ block uphill (non stop)			
41. Shopping (by yourself)			
42. Washing clothes (by Yourself)			
43. Walking 1 block on level ground			
44. Walking 2 blocks on level ground			
45. Walking 1 block on level ground (non stop)			
46. Walking 2 blocks on level ground (non stop)			
47. Scrubbing (floors, walls, or cars)			
48. Making a bed (changing the sheets)			
49. Sweeping			
50. Sweeping (five minutes non stop)			
51. Carrying a large suitcase or bowling (one game)			
52. Vacuuming the carpets			
53. Vacuuming the carpets (non stop)			
54. Painting (interior/exterior)			
55. Walking 6 blocks on level ground			
56. Walking 6 blocks on level ground (non stop)			
57. Carrying out the garbage			
58. Carrying a heavy load of groceries			
59. Climbing 24 step			
60. Climbing 36 steps			
61. Climbing 24 step (non stop)			
62. Climbing 36 steps (non stop)			
63. Walking 1 mile			

Figure 3.20. (continued) The Human Activity Profile (HAP) for items 31-63.

	Still doing this activity	*Have stopped doing the activity*	*Never did this activity*
64. Walking 1 mile (non stop)			
65. Running 110 yards (100 meters) or playing softball/baseball			
66. Dancing (social)			
67. Doing callisthenics or aerobic dancing (5 minutes non stop)			
68. Mowing the lawn (power mower, but not a riding mower)			
69. Walking 2 miles			
70. Walking 2 miles (non stop)			
71. Climbing 50 steps (2.5 floors)			
72. Shovelling, digging, or spading			
73. Shovelling, digging, or spading (5 minutes non stop)			
74. Climbing 50 steps (non stop)			
75. Walking three miles or golfing 18 holes without a riding cart			
76. Walking 3 miles (non stop)			
77. Swimming 25 yards			
78. Swimming 25 yards (non stop)			
79. Bicycling 1 mile			
80. Bicycling 2 mile			
81. Bicycling 1 mile (non stop)			
82. Bicycling 2 mile (non stop)			
83. Running or jogging ¼ mile			
84. Running or jogging ½ mile			
85. Playing tennis or racquetball			
86. Playing basketball/soccer (game play)			
87. Running or jogging ¼ mile (non stop)			
88. Running or jogging ½ mile (non stop)			
89. Running or jogging 1 mile			
90. Running or jogging 2 mile			
91. Running or jogging 3 mile			
92.Running or jogging 1 mile in 12 minutes or less			
93.Running or jogging 2 mile in 20 minutes or less			
94.Running or jogging 3 mile in 30 minutes or less			

Figure 3.20. (continued) The Human Activity Profile (HAP) for items 64-94.

3.5 Statistical analyses

Data were analysed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp. in Armonk, NY). The distribution for normality of all continuous data was examined by using skewness and kurtosis statistics and were considered normal if the value fell within the range $-2 \geq z \leq 2$ (Altman & Bland, 1996), and non-normally distributed data (skew ≥ 2.0) being analysed with non-parametric tests. The critical value for all analyses was $p<0.05$. Descriptive analysis was applied on demographic data, fall circumstances and all outcome measures. All demographic and clinical characteristics were presented as a mean (SD), median, interquartile range, or n (%) for each group. Cross tabulation analysis was applied to identify any association between fall characteristics and gender, and three age groups (50-59, 60-69, 70 and above).

The statistical analysis for each objective is described below:

a) A two-way analysis of variance was conducted to examine whether there was an interaction of two independent variable (gender and age groups) on clinical and laboratory measures of balance and mobility performance among participants. Age was categorised into three difference age group (ten years intervals) namely 50-59, 60-69, and 70 and above. Shapiro-Wilks and Levene's Test were used to evaluate the assumption of normality and homogeneity of variance respectively on each measure between male and female in each age group. Post Hoc analyses were carried out to determine between which groups mean differences were presented for the analyses involving three groups.

b) Univariate analyses were performed to establish odd ratios and 95% confidence intervals associated with falls, and variables identified to be significant at $p < 0.1$ in the univariate analysis, were then included in a multivariate regression using the enter method.

c) Factor analysis was used to identify the interrelationship between the balance and mobility assessment measures to refine the assessment suite. Factor Analysis using the Principal Component Analysis using varimax (orthogonal) rotation method with Kaiser Normalization was performed for clinical and laboratory measures of balance. Extraction of factors was based on the principal factors solution and varimax rotation, and each factor was interpreted considering factor loading. Scree plot and factor loadings greater than 0.3 on the matrix were considered in determining the number of factors.

Power analysis and sample size calculation are reported in Section 3.3.2.

3.6 Permission and ethical considerations

Human Ethics (For projects involving human participants / tissue). The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number FHEC11/099 (Appendix 7), La Trobe University Ethic Committee for Study 1 (Appendix 8) and the Research Ethics Committee of Universiti Putra Malaysia, (Appendix 9). All participants read a plain language Participant Information Form, and had the opportunity to have questions related to participation answered by the researcher, before providing written consent to participate in the project.

3.7 Safety considerations

To ensure safety during the first two force platform standing tests, a safety jacket was fitted to the participant, and the harness was attached to an overhead rail. The harness was fitted so as not to inhibit trunk movements during postural responses, but to steady the person if they start to overbalance. During all other clinical and force platform tests, the participant was closely supervised by the trained assessor. Participants were allowed to have rests if required during the assessment.

STUDY 2: EFFECTIVENESS OF INDIVIDUALISED HOME BASED EXERCISE ON IMPROVING TURNING, BALANCE AND MOBILITY PERFORMANCE AMONG ADULTS AGED 50 YEARS AND ABOVE: RANDOMISED CONTROLLED TRIAL

The methods for this randomised controlled trial have been published in a study protocol paper: Asmidawati, A., Hamid, T. A., Hussain, MR., & Hill, K.D. (2014). Home based exercise to improve turning and mobility performance among community dwelling older adults: protocol for a randomised controlled trial, *BMC Geriatrics, 14* (1), 100**.** A copy of this paper is included in Appendix 1.

3.8 Aims, research design and procedures

The aim of this study was to evaluate the effectiveness of a 16 week individualized home based exercise program in improving turning performance and common balance impairments among community dwelling adults aged 50 years and above, who had impaired turning performance. It was hypothesized that the intervention group could improve turning, balance and mobility performance relative to a control group.

3.9 Study design

This study was a single-blind randomised controlled trial where the assessors were blind to group allocation. The study was registered at the Australian New Zealand Clinical Trial Registry (ACTRN12613000855729). The development of the methodology framework for this study was based on the CONSORT statement (Schulz et al., 2010). A flow diagram of the study is illustrated in Figure 3.21.

3.9.1 Participants and recruitment

Participants were recruited through the distribution of flyers and on a voluntary basis from the membership of the University of the Third Age (U3A) of Malaysia, hosted at the Institute of Gerontology, Universiti Putra Malaysia. The University of the Third Age (U3A) Malaysia is a program that provides lifelong learning courses to adults aged 50 years and above. Potential participants received a detailed explanation of the proposed study including aims, potential benefit and risk, and expected time commitment associated with participation.

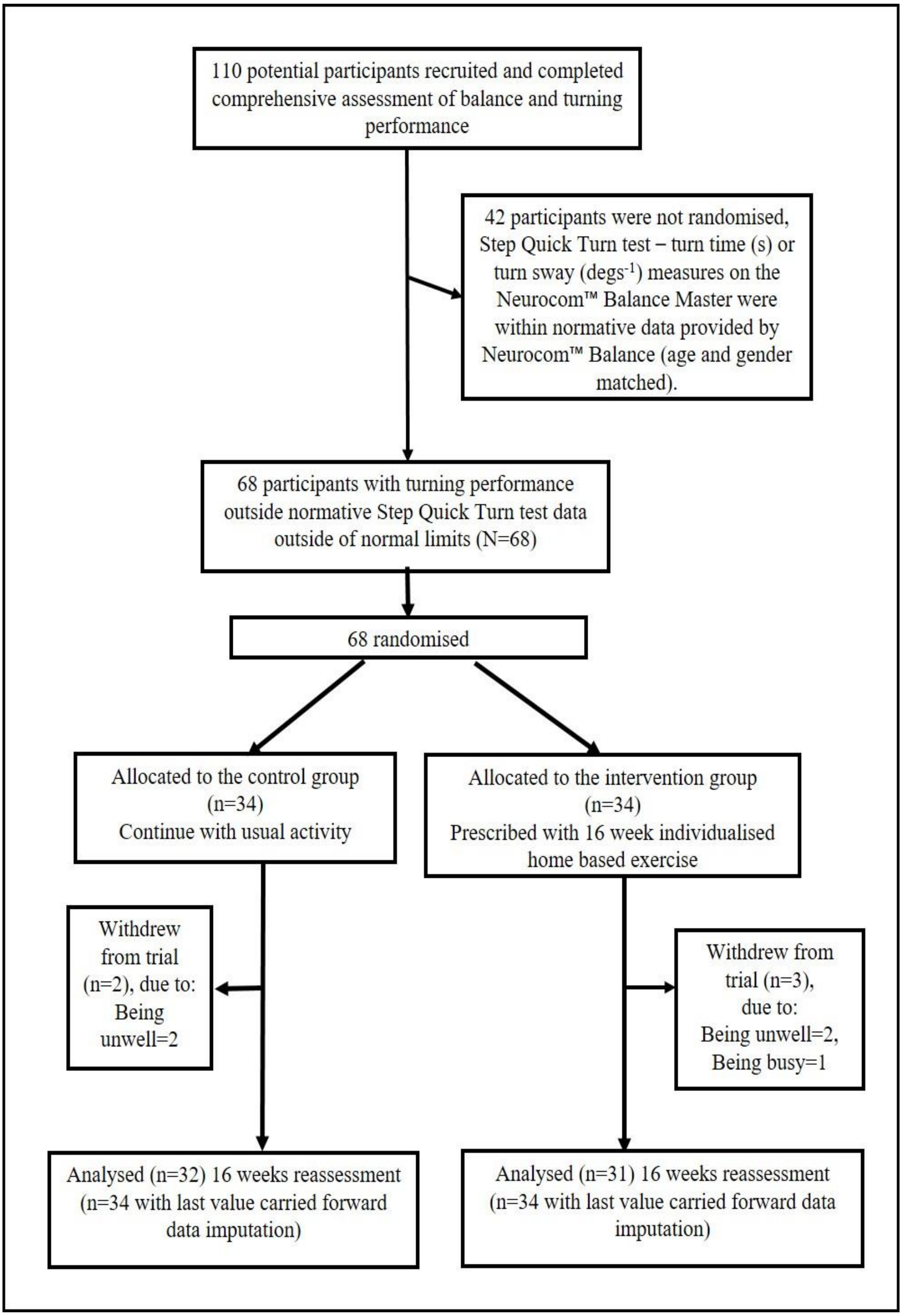


Figure 3.21: Diagram of participant flow through the trial

Note: SQT = Step Quick Turn

Eligible participants were screened on a single occasion prior to the baseline assessment to ensure they met the study inclusion criteria, which were: i) being identified as having performance on the Step Quick Turn test on the Neurocom™ long force platform outside of normal limits (based on age and gender normative data for this test on the Neurocom™ system), ii) being community-dwelling, iii) being aged 50 years and over (this age cut-off was used because of the relatively shorter life expectancy in Malaysia compared to many countries with more advanced population ageing), iv) able to tolerate standing and walking independently for at least six minutes, v) being community ambulant, and vi) having no major neurological history (e.g. stroke with unilateral or bilateral paresis, multiple sclerosis) or orthopedic history that impacts on functional mobility.

Participants were excluded if they: i) had severe clinical or musculoskeletal impairment such as fractures that affected mobility and function, ii) had visual or auditory impairment which cannot be corrected (e.g. with glasses or hearing aids), iii) had a past history of stroke, Parkinson's disease, cardiac problem, or transient ischemic attacks, or iv) were aged less than 50 years old.

3.10 Assessments

The assessment battery was conducted at the Gerontology Laboratory, Institute of Gerontology, University Putra Malaysia, at baseline and 16 weeks later. The assessor (blind to group allocation) received formal training to carry out the clinical and laboratory measures of balance was assisted by one research assistant (a qualified physiotherapist) who received training on the assessment procedures by the PhD candidate. Assessments being used for the RCT study were listed as Table 3.1 in the first part of this chapter. The details of clinical and laboratory measurement protocol at the baseline and reassessment for the RCT study were similar to those reported for Study 1. The assessment took approximately 90 to 120 minutes for each assessment occasion (baseline and reassessment).

All assessments in this study were carried out by a trained researcher. Participants wore a safety jacket and harness during two of the standing Neurocom™ force platform balance assessments (mCTSIB and LOS, see section 3.4.2.2), to avoid risk of overbalancing, and were also closely supervised by the assessor during all tests.

3.11 Randomisation

All eligible participants were randomised to either the intervention group or the control group based on a concealed randomisation procedure using a computer generated random numbers table. This table designated the order of numbers (of participants) into "1" and "2", where "1" represented the control group and "2" represented the exercise group. Group allocation for each participant number was folded and placed in an opaque envelope with numbers consecutively from 1-68 (the required sample size, see section 3.14) numbered on the outside, and sealed by a researcher independent of the assessors. Group assignment was carried out consecutively after the baseline assessment, at which time each participant was informed as to which group they were allocated.

3.12 Intervention and control activities

Participants allocated to the intervention group were requested to perform an individualized home based exercise program at least four times per week for 16 weeks. This exercise program was adapted from the Otago Exercise Program (Campbell et al., 1997a), which includes balance and strengthening exercises, but each person's program was modified to also include two additional exercises focused on improving turning performance.

A previous meta-analysis of the Otago individualized tailored home exercise program demonstrated the program to be effective in reducing falls related injuries by 35% in older people and those with increased risk of falls (Robertson et al., 2002). The dosage for the adapted Otago exercise program in this study is consistent with recommendations from a meta-analysis of exercise interventions in reducing falls (Sherrington et al., 2011).

The selection and number of exercises for each participant in the intervention group was based on assessment findings of level and areas of impairments. Most of the participants received six to eight exercises, which took approximately 20-30 minutes per session on average, including rests. Two of the six to eight exercises prescribed were selected to improve turning ability, while the other exercises were targeted to improve identified balance and mobility impairments. Intervention participants were asked to perform the exercise program at least four times per week at home. Exercise progression was dependent on the ability of the participant and their improvement over time. The exercise progression was increased gradually by increasing the number of repetitions, increasing amplitude of an exercise, reducing base of support, and /or reducing support (Table 3.2). In addition to the balance, strengthening and mobility (including turning) exercises, a graduated walking program was integrated into the 16 weeks intervention, at least three times per week, with gradually increasing distances. Participants were asked to record the exercises performed and walking activity in exercise diaries provided for this purpose (Figure 3.22).

Participants in the exercise intervention were asked to visit the assessment laboratory for three occasions during the 16 week period (one visit after 3, 6 and 9 weeks) for review, modification of exercises (if indicated) and motivation to persist with the exercise program. Exercise diaries were returned to the researcher during each visit. For safety precautions, participants were advised to perform the exercises near a sturdy bench or chair on each side and wall behind for the purpose of immediate support if required.

Participants in the control group were asked to continue with their usual activities for 16 weeks, following the baseline assessment and randomisation.

Both the intervention and control group received four phone calls interspersed over the 16 week period (weeks 4, 8, 12 and 16) by a researcher blind to group allocation to obtain details regarding any falls that occurred between phone contacts. The program of the RCT study was summarized as in Table 3.3.

As for Study 1, a fall was defined as "an unexpected event which results in a person coming to rest advertently on the ground or other lower level, other than as a consequence of sustaining a violent blow, loss of consciousness or sudden onset of paralysis as a stroke or epileptic seizure" (Gibson et al., 1987, p. 4).

3.12.1 Home based exercise program

The individualised home based exercise program was delivered by the PhD researcher over a 16 week duration. The PhD researcher who delivered the exercise program received formal training in exercise prescription from an experienced physiotherapist .

Table 3.2: Exercise prescription and level of progression for strengthening, balance and turning component and walking program

Warming Up	Level 1	Level 2	Level 3	Level 4	Progression
- Neck turning - Trunk turning - Trunk extension - Ankle plantar and dorsiflexion -					
Strengthening					
- Sit to stand	5 stands with 2 hands support	5 stands with one hand support	10 stands without support	Without support 10 repetition	Able to complete 2 sets of 10 repetitions before progress to next level or number of repetitions before fatigue
		10 stands 2 hand support	10 stands one hand support		
- Knee bend (squat)	10 repetitions with support	10 repetitions no support	10 repetitions, no support (repeat 2 times)	10 repetitions, no support (repeat 3 times	Progress to lower squat or less fast
		10 repetitions, hold support (repeat 2 times)			
- Step out to side and back	10 repetitions with support	10 repetitions without support	15 repetitions without support	15 repetitions without support (repeat 2 times)	With support or without support
	10 repetitions without support	10 repetitions without support (repeat 2 times)	15 repetitions without support (repeat 2 times)		Number of repetitions before fatigue

Table 3.2: Continued

Exercise	Level 1	Level 2	Level 3	Level 4	Progression
- March on spot on foot	30 seconds no support				Number of repetitions before fatigue
- March on spot on heels	30 seconds with support	30 seconds no support	60 seconds with support	60 seconds no support	
- March on spot on toes	30 seconds with support	30 seconds no support	60 seconds with support	60 seconds no support	
Balance					
- Tandem stance (heel to toe)	10 seconds no support				Able to complete the task without support
- Tandem walk (forward)		Walk 10 steps with support (repeat 2 times	Walk 10 steps no support (repeat 2 times)		
- Tandem walk (backward)			Walk 10 steps with support (repeat 2 times)	Walk 10 steps no support (repeat 2 times)	
- Rock on to heels	10 times no support	20 times no support			
- Rock on to toes	10 times no support	20 times no support			
- Heel walking			Walk 10 steps with support (repeat 2 times)	Walk 10 steps no support (repeat 2 times)	Progression of rock on heels
- Toe walking			Walk 10 steps with support (repeat 2 times)	Walk 10 steps no support (repeat 2 times)	Progression of rock on toes
- One leg stand (repeat for each leg)	15 seconds with support	15 seconds no support	30 seconds no support	60 seconds no support	
- Stepping diamond shape	10 times no support	15 times no support	30 times no support	60 times no support	
- March on spot			Higher / slower leg lift	Higher / slower leg lift	

Table 3.2: Continued

Exercise	Level 1	Level 2	Level 3	Level 4	Progression
Turning					
- 90 degree turns on the spot	5 repetitions	10 repetitions	15 repetitions	20 repetitions	Able to complete the task without support
- Figure 8 walk	Once in each direction	Twice in each direction	Once in each direction (narrow width)	Twice in each direction (narrow width)	
- Step across body	10 repetitions each leg				
- Braiding		5 steps and turn	10 steps and turn	15 steps and turn	
Walking					
-					
- Walking 1-2 minutes longer	15 minutes walk at normal pace (participant started walking program and gradual increase by 1 to 2 minutes				Participants were asked the time they spend for outdoor walking at usual pace. Additional 1 to 2 minutes to their usual time they spend for walking

Participant Exercise Diary (Diari Senaman Peserta)

Instruction:Please tick (/) when you completed your exercise for that day and write a 'W" for the day when you have gone for walk. Leave any comment if you not able to perform the exercise of that day. Kindly bring this form during next appointment.														
Arahan: Sila tandakan (/) sekiranya anda melengkapkan setiap senaman dalam hari tersebut dan tuliskan "W" untuk hari yang anda keluar melakukan senaman berjalan kaki.Nyatakan sebarang komen sekiranya anda tidak dapat melaksanakan senaman pada hari tersebut. Sila bawa borang ini pada temujanji yang akan datang).														
Name of Participant:														
Week ____														
Date:														
Exercise	Day 1	Comments	Day 2	Comments	Day 3	Comments	Day 4	Comments	Day 5	Comments	Day 6	Comments	Day 7	Comments
Warming Up														
Neck turning														
Trunk turning														
Trunk extension														
Ankle plantar and dorsiflexion														
Strengthening														
Sit to stand														
Knee bends (squat)														
Step out to side and back														
March on spot on foot														
March on spot on heels														
March on spot on toes														
Balance														
Tandem stance (heel to toe)														
Tandem walk (forward)														
Tandem walk (backward)														
Rock on to heels														
Rock on to toes														
Heels walking														
Toes walking														
One leg stand (repeat for each leg)														
Stepping diamond shaped														
March on spot with														
Turning														
90 degree turns on the spot														
Walk and Turn (Figure 8 walk)														
Step across body														
Braiding														
Walking														
Walk 1-2 minutes longer														
Stair walk														

Figure 3.22: Exercise diaries (exercises not selected were crossed out).

Table 3.3. Program schedule for the laboratory visit and follow up phone calls of fall monitoring for intervention and control group

Week / Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Baseline Assessment	*																
Laboratory visit [b]			x			x			x								
Follow -up Phone call for fall monitoring [a]				#				#				#				#	
Reassessment																	*

Note.: [a] Both groups (Intervention and Control) involved. [b] Intervention group only

.

Each intervention group participant was given an exercise booklet and exercise diary at the initial laboratory visit. The exercise booklet contained the instructions and pictorial images for each chosen exercise (for example, see Figure 3.23). The booklet also contained information about the aims of the exercise program, safety precautions including the place where the exercise should be performed (near the sturdy table, chair or wall), and advice that the exercises should be avoided if the participant experienced dizziness, chest pain or shortness of breath or felt unwell, and the researcher be contacted in such circumstances.

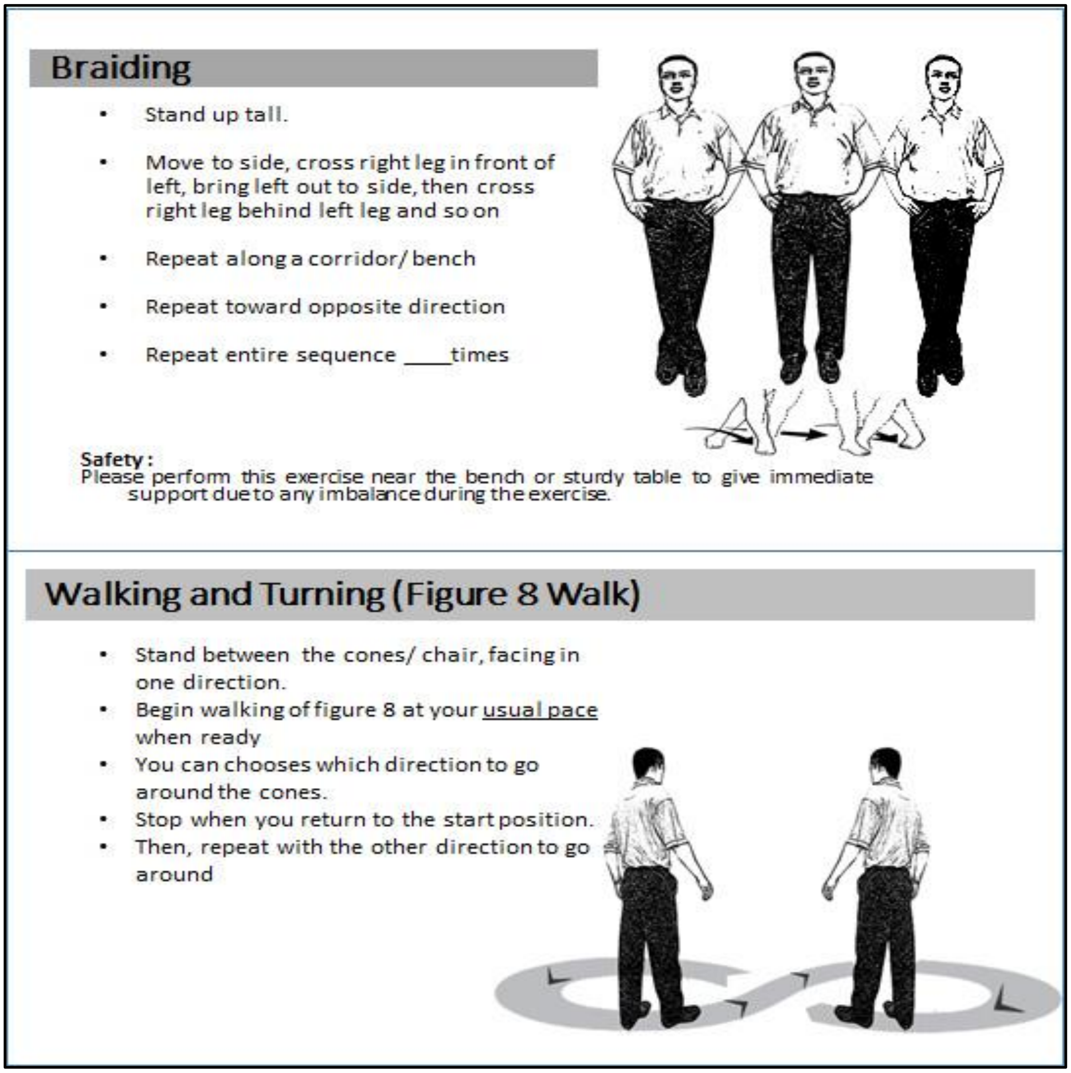


Figure 3.23. Example of pictorial instruction in the exercise sheet.

3.13 Outcome measures

The primary outcome variables in this study were the turn sway and turn time variables from the Step Quick Turn measure on the Neurocom™ Balance Master. Secondary outcome variables were: time taken to complete the Timed Up and Go test with single and dual task, the Step Test, Functional Reach test and level of physical activity (HAPAAS), and other variables from the Neurocom™ Balance Master tests: Walk Across (step width), Sit-To-Stand (degree of sway, weight transfer, time taken to stand up and rising index), Limits of Stability (movement velocity and reaction time in seconds) and exercise adherence (number of exercise sessions per week).

3.14 Statistical analyses

Power analysis was performed for the primary outcome measure (Step Quick Turn test on the Neurocom™ Balance Master), based to the mean score for the step Quick Turn Test (sway degree/second) result from a previous exercise intervention trial of older with mild balance impairment (Yang et al., 2012). It was estimated that 34 participants per group (68 participants in total) were required for this study to have at least 80 percent power to detect a 15 percent improvement in the Step Quick Turn test using the turn sway measure on the Neurocom™ Balance Master Long Force Plate. This calculation was based on assuming a 50% standard deviation improvement with the intervention [SD = 10.2, effect size =0.5 (medium to large effect)] at $P < 0.005$ (two-tailed). This calculation includes allowance for an anticipated 20% dropout rate. This sample size was also calculated to be sufficient for the other secondary outcome measures proposed in this study.

Data were analysed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp. in Armonk, NY). All analyses were conducted using the intention to treat principle. Baseline demographic and clinical characteristics were presented as a mean (SD), median, interquartile range, or n (%) for each group. Comparisons of the baseline characteristics of the participants in the two groups were analysed using Fisher's exact test and Chi-square test for categorical data and independent Student's *t*-test for continuous data. Data were inspected for normality before use in analysis. Missing data due to drop outs were imputed using the last value carried forward (LOCF) (Molnar et al., 2008). A two way between group analysis of variance (ANOVA) with repeated measures was applied to identify the effect of the exercise intervention on the turning and balance measures. Any baseline differences between groups were included as covariates in the analysis. Effect sizes (mean change/pooled SD) were calculated for the intervention group for the outcome measures.

3.15 Permission and ethical considerations

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number FHEC: PT231/2013, Approval Date: May 30, 2013. Actual data collection occurred at the Institute of Gerontology, University Putra Malaysia, resulting in the need for the additional ethical clearance by the Research Ethics Committee of University Putra Malaysia (Appendix 11). Permission was also obtained to conduct research in Malaysia from authorities in the Economic Planning Unit (EPU), Department of the Prime Minister of Malaysia (Appendix 12).

CHAPTER 4

FALL PREVALENCE AND FALL RISK ASSESSMENT AMONG COMMUNITY DWELLING ADULTS AGED 50 YEARS AND ABOVE IN MALAYSIA: CROSS-SECTIONAL STUDY

4.0 Introduction

Falls are common events among older people and have become known as one of the "giants" of geriatric medicine (Clements, 2008; Close, 2001). Due to the increasing falls prevalence with increasing age (Cumming, 1998) and the unprecedented rate of aging populations worldwide (Kinsella & Velkoff, 2001) falls have become one of the most common and serious health problems in older adults (Abbott, 2009; Speechley, 2011). A recent review of epidemiological studies of falls across countries indicated that the reported range of falls rates in the community setting for older people varies between 20 to 33% (Peel, 2011), though most commonly these have been reported between 30-35%. These falls resulted in serious injuries in 10-20% of cases and 2-6% resulted in a fracture or other serious injuries requiring hospitalisation (WHO, 2007).

Although there are many studies of falls risk factors and falls prevention interventions, the majority of these have been undertaken in Western countries (Deandrea et al., 2010). There have been a small number of studies that have reported falls incidence in Asian nations, such as Taiwan (Chang et al., 2010; Kwan et al., 2013b), Japan (Kojima et al., 2008), Korea (Eun et al., 2015; Sohng et al., 2004), Hong Kong (Chu et al., 2005), Singapore (Chan et al., 1997), and Thailand (Assantachai et al., 2003) (see Chapter 2.3). These few studies have reported generally lower rates of falls, between 10 to 33 percent of older people falling in Asian countries in a 12 month period (Hua et al., 2007; Kwan et al., 2011a). Differences in age, racial background, socio-demography, environment and population settings, lifestyle (diet, activity, sunlight exposure), body dimensions, and culture between countries might all contribute to the differences of fall prevalence, circumstances and consequences of falls across different regions of the world (Bekibele & Gureje, 2010). Additionally, differences in sampling, recruitment and methods of data ascertainment (retrospective vs prospective falls data), and possibly cultural differences in willingness to report specific health problems such as falls, may account for some of these differences. Research is needed to identify prevention strategies that will be effective in different cultural contexts (WHO, 2007).

Recently, the older population in Malaysia is growing rapidly. In 2007, there were 1,195,480 people aged 65 years and above, which represented 4.41% of the total population (Ong et al., 2009). It was projected that by the year 2019 the population aged 65 and above would reach seven percent (Ruziaton et al., 2006) and Malaysia will become an aged nation by the year 2030 whereby the older population comprises 15% of the total population (Hamid, 2012; Ruziaton et al., 2006). This demographic change will result in older people forming a more significant part of the Malaysian society.

This situation creates the need for preventive action to minimize the impact of the problems associated with ageing, such as falls. Furthermore, initial identification which may involve comprehensive assessments of falls risk factors could minimize the likelihood of progression of falls risk (as stated in Chapter 2.4) and provide a basis to inform effective fall prevention program at early stages of risk for the older population. Ideally, the magnitude of the problem of falls and associated contributory factors needs to be defined in the Malaysian context, and management strategies should be designed within the context of local needs and the Malaysian primary and public health care systems.

The current chapter provides results for a cross-sectional study of falls prevalence and fall risk assessment carried out among 156 Malaysian adults aged > 50 years. The findings for this study are presented in four sections to address the specific research aims as below:

Section I: To identify the prevalence and circumstances of falls in the previous 12 months among community dwelling Malaysian adults aged 50 years and above.

Section II: To examine the effect of age and gender on clinical and laboratory measures of balance, mobility performance and psychometric measures among community dwelling Malaysians aged 50 years and above.

Section III: To identify the risk factors that differentiate fallers and non fallers among community dwelling Malaysians aged 50 years and above.

Section IV: To identify a reduced suite of balance and mobility assessment measures for community dwelling Malaysians aged 50 years and above, based on factor analysis.

The cross-sectional study consisted of 156 adults aged > 50 years. Convenience sampling was used to recruit from the University of the Third Age (U3A) Selangor and Kuala Lumpur, Malaysia, from the group based at the Institute of Gerontology, Universiti Putra Malaysia. Details of inclusion and exlusion criteria, and approach for recruitment for this study have been described in Chapter 3.3. Data collection was carried out from September 2011 until April 2012. Face to face interviews were conducted by trained researchers based on a structured questionnaire and a series of physical performance tests, and clinical and laboratory measures of balance and mobility as summarised in Table 3.1, Chapter 3.

All clinical and laboratory measures of balance, physical assessments, and interviews were carried out at the Gerontology Laboratory, Universiti Putra Malaysia. On average, the total assessment took approximately one and half hours. None of the participants required rests during the testing, even though they were permitted to have short rests as requested, and no adverse events were occurred during assessment. A detailed description of each test procedure has been reported in Chapter 3.4. In this study, a fall was defined as "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 epileptic seizure" (Gibson et al., 1987)p. 4 .

Statistical Analysis

Descriptive statistics of frequency, percentage, mean, and standard deviation were used to describe the characteristics of the participants, falls circumstances and all outcome measures. For continuous data, means, standard deviations, median, range and skew were assessed (skew criterion <2). The distribution of all continuous data was reviewed using the Shapiro Wilks Test, with non-normally distributed data being analysed with non-parametric tests.

Details of the analyses are described in Chapter 3.5. Participants who reported one or more falls in the preceding 12 months were categorized as a faller, and those who did not report any falls in the preceding 12 months were categorized as non fallers. Independent T-Tests were used for continuous normally distributed variables, and the Mann-Whitney U test (for non-normally distributed variables) was used to differentiate between fallers and non fallers. Chi-squared cross-tabulation tests were applied for categorical variables.

Two-way ANOVA was performed to examine whether there was an interaction between gender and age on clinical and laboratory measures of balance and mobility among participants. Age was categorized into three age groups (ten year intervals) namely 50-59, 60-69, and 70 and above. Shapiro-Wilks and Levene's Test were used to evaluate the assumption of normality and homogeneity of variance respectively on each measure between genders in each age group.

Univariate analyses were performed to establish Odd Ratios and 95% confidence intervals for variables associated with falls. Variables with a $p<0.1$ in the univariate analyses were then included in a multivariate regression using the enter method.

Factor Analysis using the Principal Component using varimax (orthogonal) rotation method with Kaiser Normalization was performed for clinical and laboratory measures of balance. Extraction of factors was based on the principal factors solution and varimax rotation, and each factor was interpreted considering the individual variables loading onto each factor. Scree plots and factors loading greater than 0.3 in the pattern matrix were considered in determining the number and nature of factors.

All analyses were conducted using SPSS Versions 22.0, and the level of significance criterion for all analyses was set at $p<.05$, unless otherwise stated.

4.1 Section I: Prevalence of falls and circumstances of falls among community dwelling Malaysians aged 50 years and above

4.1.1 Participant characteristics

Socio-demographic profile

A total of 156 participants were assessed in this study. The socio-demographic characteristics of participants are summarised in Table 4.1. The age of participants ranged from 50 to 78 years old, with median age being 63.0 years (*IQR* = 6.5), and more than half of the participants (56.4%) were females. The majority of participants were Malays (83.3%) and 16.7% were non Malays (consisting of 10.3% of Chinese and 6.4% Indian). Most participants were married (76.3%) and 23.7% were currently unmarried due to either divorce, being widowed or never married. In terms of living arrangements, most participants lived together with their spouse, or with spouse and their children. Only 6.4% of participants were currently living alone. On average, participants reported having three to four children.

All participants in this study were able to write and read, either in Malay or English or both, and were cognitively intact based on the AMTS score (*M* = 9.40, *SD* = 0.81). In terms of the education level, more than half of participants (54.5%) have received up to 11 years of formal education which refers to having had a formal schooling period from primary level up to secondary level, and about 32% had received tertiary education. One hundred and twenty six participants were currently not working (80.8%) and the remaining were still working. For those who were not working, 92 participants (73.0%) were retirees as a government pensioner and 34 participants (27.0%) were never employed. The median monthly income of participants was MYR1900 ($AUD614.46) based on the currency exchange as at September 28, 2015, with minimum income MYR200 ($AUD64.68) up to maximum MYR10,000 ($AUD3233.99), received from salary, pension, shares, spouse, financial support from their children or as combination of these.

Table 4.1: Socio demographic profile of participants (*N* = 156).

Variables	*M* (SD)/ *Mdn*, [IQR]	Percentage (%)
Age	63.0 (6.5)	
Gender		
Male		43.6
Female		56.4
Ethnicity		
Malay		83.3
Non Malay		16.7
Marital Status		
Married		76.3
Divorced/ widowed/ Never Married		23.7
Living Arrangement		
Lived alone		6.4
Lived with spouse only		26.3
Lived with children		49.4
Lived with others		17.9
No. of children	3.6 (2.1)	
Cognitive score (AMTS)	9.4 (0.8)	
Education Level		
Primary (6 years of formal education)		13.5
Secondary (Up to 11 years of education)		54.5
Tertiary (More than 11 years of education)		32.0
Monthly income	MYR1900, [MYR2000]	
Employment status		
Not working (never work and retirees)		80.8
Still working		19.2

Note. M = mean; SD = standard deviation; Mdn = median; IQR = interquartile range; AMTS = Abbreviated mental Test Score; MYR = Malaysian Ringgit; Currency exchange as at 28/09/2015, 1AUD = MYR 3.02

Physical and medical profile

Physical characteristics and medical profile of participants are shown in Table 4.2. Participants' mean height in (cm) and weight in (kg) were (M = *155*, SD = *8.1*) and (*M* = 66.2, *SD* = 13.3) respectively. Three quarters of participants (76.8%) were classified as having abnormal body mass index (BMI), based to the WHO recommendation (2004), with approximately 48% of the participants categorised as being overweight (BMI >24.9kgms^{-2} up to 30kgm^{s-2}), 28% categorised as obese (BMI >30.0kgm^{-}2), while only 0.8% of participants were underweight (BMI <18.5kgms^{-2}). In terms of health and medical conditions, ninety six participants (61.5%) reported having at least one health problem and among those who were diagnosed with a medical condition, about 26% had three or more health problems that might affect their balance and mobility performance. The most common self-reported health conditions were diabetes mellitus (31%), arthritis (27%), cardiac problems (24%) and back pain (24%).

Thirty percent of participants reported taking three or more types of medication daily, and central acting analgesics (24%) were the most commonly prescribed medication, followed by diuretics (21%), digoxin and type 1 antiarrhythmic (15%) respectively. Eighteen percent of participants had incontinence problems, and 82% reported that they had to go to the toilet more than three times during the night time. Almost all participants (92%) perceived their current health status as good and 76 % of participants were satisfied with their current quality of life.

The fall risk assessment indicated that 118 participants (75.6%) had four or more fall risk factors, identified in the combination of 13 domains measured using the FROP-Com assessment tool (*M* = 7, I*QR* = 7.0). None of the participant reported having uncorrected vision that affect their functional ability. More than half of participants (70%) are able to identify the edge contrast accurately and were classified as “good” based on the MET score (20 to 23) and only 10% reported experiencing somatosensory problems such as numbness. About 41% of participants were identified as having foot problems such as bunion, swelling or corns. In terms of assistive devices, only two participants were using a single point stick during outdoors activity.

Table 4.2: Physical and medical profile of participants (*N* = 156).

Variables	*M* (SD)/ *Mdn* [IQR]	Percentages (%)
Height (cm)	155 (8.1)	
Weight (kg)	66.2 (13.3)	
BMI ($kgms^{-1}$)		
Underweight (less than 18.5)		0.8
Normal (18.5 -24.9)		23.1
Overweight ≥ 25		48.1
Obese		28.0
Number of health conditions		
None		38.5
1-2 conditions		44.2
3 or more conditions		17.3
Medical problems		
Diabetes mellitus		30 (19.2)
Arthritis		26 (16.7)
Cardiac problems		23 (14.7)
Back pain		23 (14.7)
Dizziness		19 (12.2)
Neurological condition		19 (12.2)
Respiratory problem		13 (8.3)
Osteoporosis		7 (4.5)
Number of prescribed medications		
No medication		36.1
1-2 medications		33.8
3 or more medications		30.1

Note. M = mean; SD = standard deviation; Mdn = median; IQR = interquartile range; BMI = Body Mass Index

Table 4.2: (continued) Physical and medical profile of participants (*N* = 156).

Variables	*M* (SD)/ *Mdn* [IQR]	Percentages (%)
Type of medication		
Central acting analgesic		38 (24.4)
Diuretic		33(21.2)
Digoxin		23 (14.7)
Type 1 antiarrhythmic		23 (14.7)
Incontinence		28 (17.9)
Had history of fall (One or more falls in previous 12 months)		31.4%
Physical Activity level (HAPAAS)	73.6 (10.8)	
Exercise level		
Very active (exercise 3 times/week)		82 (52.6)
Moderately active (less than 2 times/week)		79 (47.4)
Risk of falls (FROP-Com Score)	7 [IQR=7]	
Visual Contrast Sensitivity (MET Score Category)	20.9 (1.82)	
Excellent (24)		12.8
Good (20-23)		69.9
Fair (16-19)		15.4
Poor (1-15)		1.9

Note. M = mean; SD = standard deviation; Mdn = median; IQR = interquartile range; HAPAAS= Human Activity Profile Adjusted Activity Score; FROP-Com= Falls Risk for Older People – Community; MET= Melbourne Edge Test

Activity level was measured using the 94 Human Activity Profile (Fix & Daughton, 1988). For the purpose of analysis, the Adjusted Activity Score was calculated as described in Chapter 3.4.6. Overall, the mean score for the Adjusted Activity Score was 73.6 (*SD* = 10.8). Bivariate analysis indicated that the Adjusted Activity Score was negatively correlated with age (r = - 0.466, p<.001). One way Analysis of Variance showed that the difference in activity scores between age groups was significant, $F(2,155) = 24.29$, $p < .001$. Post -hoc analyses using Tukey HSD revealed that the youngest age group had significantly higher physical activity ($M = 80.5$, $SD = 8.7$) compared to the older two age groups. Results also indicated that the 60-69 age group (*M* = 72.7, *SD* = 9.5) had significantly higher activity level compared to the 70 year and older group (*M* = 67.3, *SD* = 10.3). More than half of participants (52.6%) reported performing exercise three times in a week.

Psychological profile

In terms of psychological aspects related to falls, two measures were carried out to identify: i) fall efficacy, and ii) level of depression. Fear of falling was assessed using the FES-I tool. The mean FES-I score was *M* = 17.6 (*SD* = 6.1). More than half of participants were not concerned about falling during dressing or undressing, whilst 47.4% were highly concerned about falling when they were walking down a slope. Table 4.3 shows the level of concern about falling relating to each type of activity. The Geriatric Depression Scale (GDS-15) based to the categories as previously described in Chapter 3.4.3.1, indicated that the majority of participants did not have depressive symptoms, with an overall mean score of *M* = 2.1 (*SD* = 1.94).

Table 4.3: Distribution of level of concern on falls based on Fall Efficacy Scale International 7 Items (*N* = 156).

Type of activity	not at all concerned (%)	somewhat concerned (%)	fairly concerned (%)	very concerned (%)
Getting dressed or undressed	50.6	20.5	15.4	13.5
Taking bath or shower	32.1	23.7	21.2	23.1
Getting in or out of a chair	35.9	23.7	23.7	16.7
Going up or down of a stairs	19.9	26.3	25.6	28.2
Reaching for something above your head or on the ground	17.9	24.4	26.9	30.8
Walking up or down a slope	9.6	17.3	25.6	47.4
Getting out to a social event e.g: religious service, family gathering or club meeting	30.1	19.2	28.2	22.4

4.1.2 Prevalence and circumstances of falls.

Forty nine participants (31.4%) experienced at least one fall in the previous 12 months, with seven fallers (14.3%) reporting experiencing two falls within the twelve months prior to the date of interview. Out of the 49 participants who fell, 31 were female (63.3%) and 18 were males (36.7%). The proportion of falls was higher among females compared to males, however this difference did not reach statistical significance ($\chi^2(1) = 1.36$, $p = .24$). The distribution of falls prevalence by gender is reported in Table 4.4 and Figure 4.1.

Table 4.4: Distribution and Chi Square analysis of falls prevalence by gender.

	Gender		Total n (%)	p value
	Male n (%)	Female n (%)		
One or more falls in past 12 months	18 (11.5)	31 (19.9)	49 (31.4)	0.243
No falls in past 12 months	50 (32.1)	57 (36.5)	107 (68.6)	
Total	68 (43.6)	88 (56.4)	156 (100)	

Analysis of χ^2, significant differences at *p <.05. **p <.01.

All participants were categorised into three 10 year intervals of age group, which are 50-59 years, 60-69 years and 70 years and above. Eighteen fallers (36.7%) were aged 50-59, 16 fallers (32.7%) were aged 60-69 and 15 fallers (30.6%) were aged 70 years and above. There was no difference between age groups for the prevalence of falls ($\chi^2(2) = 0.65$, p =.722). The distribution of falls prevalence by age group is reported in Table 4.5 and Figure 4.1.

The circumstances of falls were obtained from the participant's explanation regarding their falls as reported in Table 4.6**.** The location of fall were classified into three main areas which were inside the home, outside the home and community areas. More than

Table 4.5: Distribution and Chi Square analysis of falls prevalence by age group.

	Age Group			Total n (%)	p value
	50-59 years n (%)	60-69 years n (%)	70 and above n (%)		
One or more falls in past 12 months	18 (11.5)	16 (10.3)	15 (9.7)	49 (31.4)	0.722
No falls in past 12 months	33 (21.2)	41 (26.3%)	33 (21.2)	107 (68.6)	
Total	51 (32.7)	57 (36.5%)	48 (30.8)	156 (100)	

Note. Analysis of χ^2, significant differences at *p <.05. **p <.01.

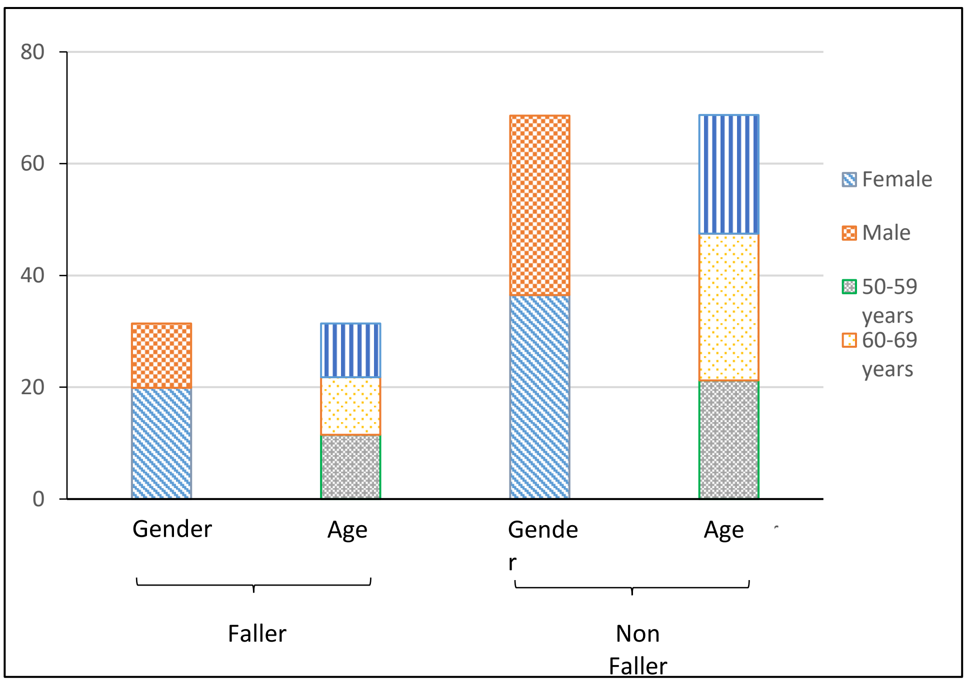


Figure 4.1: Distribution (percentage) of prevalence of falls by gender and age group.

half (63.3% of fallers) reported that they fell at home, which included falls that occurred inside and outside the home. The bathroom, kitchen and dining area, and bedroom were the most common areas where falls occurred inside the home, and the backyard area was the most prevalent area reported for falls occurring outside the home. Thirty seven percent of fallers reported falling in community areas, with the most frequent location for these falls being in front of shops, streets (including curb, uncovered drain or uneven walking paths), and park areas. More men and the younger age group reported higher rates of falls in the community areas, although these differences were not statistically significant.

Slips on wet floors, on slippery tiles, on an object such as loose rugs, and trips on curbs or uneven walking paths were the most prevalent falls causes, accounting for 75.5% of falls. Twenty five percent of falls were described as due to loss of balance and feeling dizzy. There was a significant association between gender and cause of fall, $F(2) = 6.261$, $p = 0.044$, with eight out of eighteen (44%) male fallers reporting that their falls were associated with loss of balance. There was no significant difference in the distribution of causes of falls between the three age groups. The most prevalent types of activities prior to falls were walking (61%), turning (26.5%) reaching and bending (8.2%), and standing (8.2%). Almost one third of fallers reported that they fell in the forwards direction and 18.4% fell backwards. Slightly more than half of falls reported occurred during night time.

4.1.3 Consequences of falls

Based on self-report regarding the severity of injuries incurred during falls, nine fallers (18.4%) reported no injury, while 40 fallers (81.6%) suffered injuries from their fall. More than half of fallers (71.4%) sustained minor injuries such as grazes, bruises, sprains and cuts, while 10.2% reported suffering a severe injury such as fracture or dislocation as a consequence of their fall (Table 4.7). Among those five participants who experienced severe injuries, one participant had a fractured patella, one experienced an ankle fracture, one had a wrist fracture and two had ankle dislocations. Among those fallers who had minor injuries, twenty two (62.8%) did not require medical treatment and 37.2% did seek medical attention. Even though all severe injuries were reported among female fallers and these were most prevalent in fallers in the 60-69 age group, there was no statistical association between severity of injuries between gender and age group identified.

Table 4.6: Percentage distribution and Chi Square analysis of fall circumstances by gender and age group.

	Gender		P value	Age Group			Total n (%)	p value
	Male, n (%)	Female n (%)		50-59 years n (%)	60-69 years n (%)	70 and above n (%)		
Location of fall			0.110					0.549
inside home	4 (8.2)	13 (26.6)		6 (12.2)	5 (10.2)	6 (12.2)	17 (34.7)	
outside home	4 (8.2)	10 (20.4)		3 (6.1)	6 (12.2)	5 (10.2)	14 (28.6)	
community	10 (20.4)	8 (16.3)		9 (18.4)	5 (10.2)	4 (8.2)	18 (36.7)	
Causes of fall			0.044*					0.959
trip	3 (6.1)	10 (20.4)		5 (10.2)	4 (8.2)	4 (8.2)	13 (26.5)	
slip	7 (14.3)	17 (34.7)		9 (18.4)	7 (14.3)	8 (16.3)	24 (49.0)	
loss of balance	8 (16.3)	4 (8.2)		4 (8.2)	5 (10.2)	3 (6.1)	12 (24.5)	
Time of fall			0.790					0.419
Daytime[1]	8 (16.3)	15 (30.6)		9 (18.4)	9 (18.4)	5 (10.2)	23 (46.9)	
Night time	10 (20.4)	16 (32.7)		9 (18.4)	7 (14.3)	10 (20.4)	26 (53.1)	
Total	**18 (36.7)**	**31 (53.3)**		**18 (36.8)**	**16 (32.7)**	**15 (30.6)**	**49 (100)**	

*Analysis of χ^2, significant differences at *p <.05. **p <.01.

Note. [1]Day time refers to from sunrise to sunset (approximately from 7am to 7pm based to the local time in Malaysia (GMT+8.00)

Table 4.6: (continued) Percentage distribution Chi Square analysis of fall circumstances by gender and age group.

	Gender		P value	Age Group			Total	p value
	Male, n (%)	Female n (%)		50-59 years n (%)	60-69 years n (%)	70 and above n (%)	n (%)	
Direction of fall			0.459					0.542
Forward	5 (10.2)	10 (20.4)		7 (14.3)	6 (12.2)	2 (4.1)	15 (30.6)	
Backward	5 (10.2)	4 (8.2)		3 (6.1)	2 (4.1)	4 (8.2)	9 (18.4)	
Left	3 (6.1)	4 (8.2)		2 (4.1)	2 (4.1)	3 (6.1)	7 (14.3)	
Right	1 (2.0)	7 (14.3)		3 (6.1)	4 (8.2)	1 (2.0)	8 (16.3)	
Down	4 (8.2)	6(12.2)		3 (6.1)	2 (4.1)	5 (10.2)	10 (20.4)	
Total	18 (36.7)	31 (53.3)		18 (36.8)	16 (32.7)	15 (30.6)	49 (100)	

Analysis of χ^2, significant differences at *p <.05. **p <.01.

Table 4.7: Percentage distribution and Chi Square analysis of severity of injuries related to falls by gender and age group.

	Gender		P value	Age Group			Total	p value
	Male, n (%)	Female n (%)		50-59 years n (%)	60-69 years n (%)	70 and above n (%)	n (%)	
Level of injury			0.087					0.592
No injury	6 (12.2)	3 (6.1)		3 (6.1)	3 (6.1)	3 (6.1)	9 (18.3)	
Minor injury, did not require medical attention	8 (16.3)	14 (28.6)		9 (18.4)	8 (16.3)	5 (10.2)	22 (44.9)	
Minor injury, did require medical attention	4 (8.2)	9 (18.4)		5 (10.2)	2 (4.1)	6 (12.2)	13 (26.5)	
Severe injury (fracture, dislocation)	0 (0.0)	5 (10.2)		1 (2.0)	3 (6.2)	1 (2.0)	5 (10.2)	
Total	18 (36.7)	31 (53.3)		18 (36.7)	16 (32.7)	15 (30.5)	49 (100)	

Note. Analysis of χ^2, significant differences at *p <.05. **p <.01.

4.2 Section II: Gender and age differences on balance and mobility performance

Detailed assessment of participant's balance and mobility performance was carried out. A multivariate two way analysis of variance (ANOVA) was undertaken to examine the effect of age and gender on balance and mobility performance.

In total, 13 measures of balance and mobility performance were assessed, consisting of eight laboratory measures and five clinical measures of balance which were included in the analysis. Measures of balance were compared between male and female participants across the three age groups, namely 50-59 years old, 60-69 years and 70 years and above, as listed in Table 4.8.

The two way ANOVA showed a statistically significant interaction effect of gender and age on step width (cm) for the Walk Across test, $F(2,150) = 5.225$, $p = .006$, partial $\eta 2 = .065$. This finding demonstrates that step width is statistically different between age groups and gender. A simple main effect of gender indicated that female participants had significantly narrower step width (M = 16.46, SD = 2.69) compared to males participants (M = 18.74, SD = 2.58).

Additionally, age was found to have had a significant effect on four clinical measures of balance, namely the Timed Up and Go test ($F [2,150] = 6.915$, $p = .001$, partial $\eta 2 = .084$), Timed Up and Go Dual task, $F(2,150) = 8.530$, $p =.000$, partial $\eta 2 = .102$, Functional Reach Test, $F(2,150) = 5.792$, $p = .004$, partial $\eta 2 = .072$, and the Step Test, $F(2,150) = 5.225$, $p = .006$, partial $\eta 2 = .065$. For laboratory measures using the Neurocom™ balance master force platform, three measures differed between age groups - static stance sway, mCTSIB ($F [2,150] = 8.285$, $p = .000$, partial $\eta 2 = .099$), and maximum excursion, $F(2,150) = 16.63$, $p = .000$, partial $\eta 2 = .182$ and directional control, $F(2,150) = 11.37$, $p = .000$, partial $\eta 2 = .132$, of the Limits of Stability test.

Post hoc analysis indicated that those balance measures which had a main effect of age demonstrated a significant difference between the 50-59 and 60-69 year age groups and the 70 years and above group, or between those who were aged 50-59 and the 70 years and older group. None of the post hoc analyses showed any significant differences between those aged 60-69 and 70 years and older. Results indicated that those aged 50-59 took significantly less time to complete the TUG single task (M = 9.43, SD = 1.45) compared to those aged 60-69 (M = 10.30, SD = 1.68; p

= .007) and participants aged 70 years and above (M = 10.62, SD = 1.77; p < .001), as shown in Figure 4.2.

Similar findings were identified for the Timed Up and Go with dual task, with those aged 50-59 taking significantly less time to complete the TUG task while carrying a cup of water (dual task) (M = 10.39, SD = 1.77) compared to those aged 60-69 (M = 11.72, SD = 1.98; p = .004), and participants aged 70 years and above (M = 12.31, SD = 3.04; p <.000).

Additionally, older adults aged 70 years and above were found to have significantly poorer balance (less steps on the Step Test), (M = 14.73, SD = 3.79; p = .006), compared to those aged 50-59 (M = 16.84, SD = 3.01). Similar age group differences were identified for the Functional Reach test between the 50-59 year age group and those in the 60-69 and 70 years and above age group, with a longer reaching ability in those aged 50-59 (M = 9.43, SD = 1.45), compared to those aged 60-69 and those aged 70 years and older. However, for the Limits of Stability test, the maximum distance (excursion) was only statistically different between those in the 50-59 age group (M = 88.16, SD = 9.29), and the 70 years and older group (M = 76.48, SD = 11.86). Similar differences were identified for directional control in the Limits of Stability test, with those aged 70 years and above being significantly less direct in reaching the desired target compared to those aged 50-59. In addition, the older aged group demonstrated more sway during static stance compared to the youngest aged group. There were no significant differences identified between the 60-69 and 70 years and older group on any of these measures.

The Functional Reach test was also identified to have a significant main gender effect, $F(1,150) = 4.793$, $p = .030$, partial $\eta^2 = .031$ (Figure 4.3), with males reaching further than females.

4.3 Section III: Identification of fall risk factors for falls among Malaysian adults aged 50 years and above

As reported in section 4.1.2, 49 participants (31.4%) experienced at least one fall in the previous 12 months. The prevalence rate of falls among the studied population was comparable to those reported among western populations and slightly higher

Table 4.8: Two way analysis of variance, means and standard deviations of the balance and mobility performance measures grouped by gender and age group.

Measures	Age group						P value main effect gender	P value main effect age	P value interaction effect
	50-59 years (n=51)		60-69 years (n=57)		70 and above (n=48)				
	Male *M* (SD)	Female *M* (SD)	Male *M* (SD)	Female *M* (SD)	Male *M* (SD)	Female *M* (SD)			
Laboratory measures of balance									
mCTSIB									
-Composite sway (deg/sec)	0.60 (0.40)	0.46 (0.20)	0.67 (0.32)	0.62 (0.35)	0.77 (0.33)	0.86 (0.49)	0.613	0.000**	0.251
Limit of Stability (LOS)									
- Reaction time (sec)	1.28 (0.25)	1.28 (0.23)	1.29 (0.31)	1.32 (0.25)	1.30 (0.28)	1.31 (0.25)	0.695	0.858	0.976
- Directional control (deg/sec)	74.95 (8.03)	73.13 (6.91)	74.09 (7.19)	71.30 (6.41)	67.93 (9.49)	64.38 (13.17)	0.056	0.000**	0.888
- Maximum excursion (%)	85.90 (9.96)	89.61 (8.68)	85.28 (13.27)	83.34 (7.90)	78.32 (9.84)	75.52 (15.34)	0.864	0.000**	0.273
WA, step width (cm)	18.92 (2.56)	15.60 (2.38)	18.61 (2.38)	16.97 (2.80)	17.65 (2.52)	16.85 (2.79)	0.000**	0.056	0.048*
STS, COG sway (deg/sec)	3.10 (0.82)	2.69 (0.922)	2.89 (1.02)	2.83 (0.86)	2.65 (1.01)	2.68 (0.93)	0.343	0.452	0.480
SQT, worse side									
- Turn sway (deg/sec)	51.58 (7.10)	50.86 (9.11)	48.56 (6.39)	48.80 (7.71)	49.34 (8.08)	50.53 (10.83)	0.862	0.305	0.856
- Turn time (sec)	2.41 (0.84)	2.31 (0.91)	2.31 (0.52)	2.14 (0.67)	2.40 (0.71)	2.45 (1.04)	0.565	0.431	0.778

*Statistically significant at $p < .05$, **Statistically significant at $p < .01$*. N*ote.* *M* = Mean, SD = Standard Deviation, mCTSIB = Modified Clinical Test Sensory Interaction of Balance; LOS = Limit of Stability; WA = Walk across; STS = Sit to stand; SQT = Step Quick Turn,

Table 4.8: continued

Measures	Age group						*p* value main effect gender	*p* value main effect age	*p* value interaction effect
	50-59 years (n=51)		60-69 years (n=57)		70 and above (n=48)				
	Male *M* (SD)	Female *M* (SD)	Male *M* (SD)	Female *M* (SD)	Male *M* (SD)	Female *M* *M*(SD)			
Clinical measures of balances									
Timed up and Go									
- Single task (sec)	9.45 (1.19)	9.42 (1.61)	11.08 (2.08)	10.34 (1.96)	10.43 (2.17)	10.48 (1.71)	0.419	0.001**	0.480
- Dual Task (sec)	10.60 (1.39)	10.26 (1.98)	12.00 (1.87)	11.50 (2.06)	12.48 (3.13)	12.16 (3.01)	0.305	0.000**	0.976
Functional Reach Test (cm)	31.00 (4.95)	29.29 (4.93)	28.7 (4.99)	26.24 (5.82)	27.87 (5.31)	26.20 (4.8)	0.030*	0.004**	0.858
ST, worse leg stepping (no. of step/ 15 sec)	16.80 (3.02)	17.23 (3.37)	15.08 (3.57)	15.34 (3.30)	15.91 (4.49)	15.60 (3.74)	0.830	0.006**	0.868
FTSST (sec)	17.10 (6.50)	17.90 (5.64)	17.88 (5.91)	16.91 (5.36)	18.39 (6.02)	16.52 (5.58)	0.470	0.995	0.513

*Statistically significant at $p < .05$, **Statistically significant at $p < .01$*.

Note. M = Mean, SD = Standard Deviation, *$p < .05$; mCTSIB = Modified Clinical Test Sensory Interaction of Balance; LOS = Limit of Stability; WA = Walk across; STS = Sit to Stand; SQT = Step Quick Turn; ST = Step Test; FTSST = Five Times Sit to Stand Test.

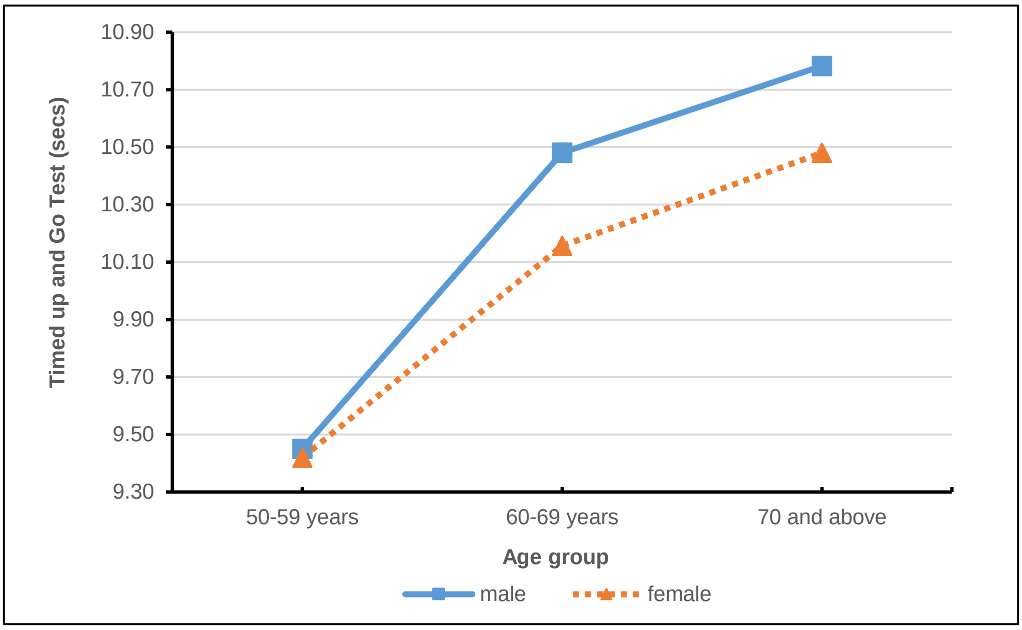


Figure 4.2: Timed Up and Go test score by age and gender. Two way ANOVA showed a significant age effect ($p \leq 0.05$) for the Timed Up and Go test.

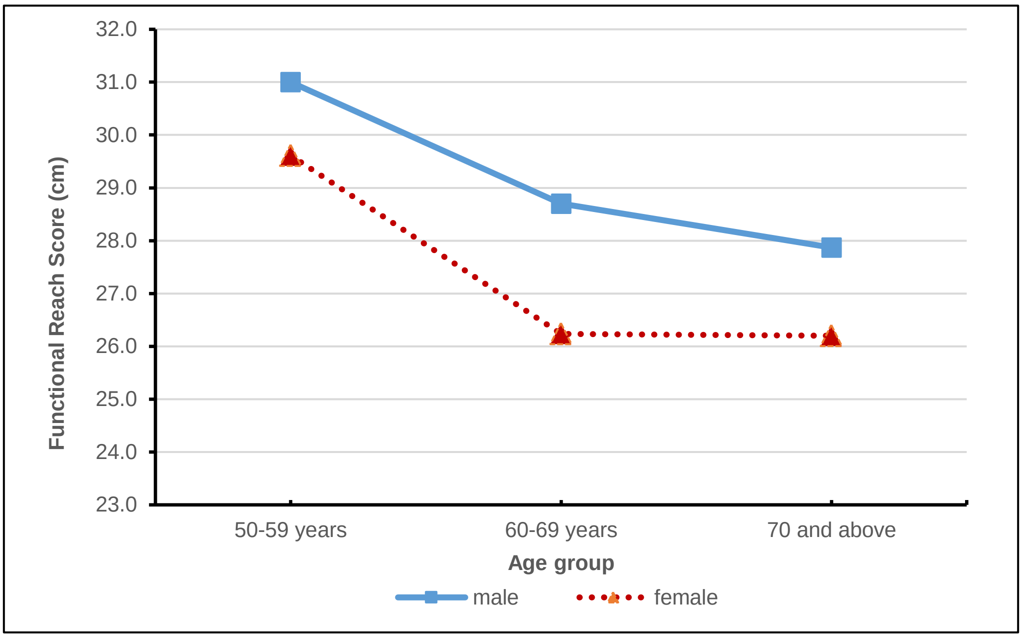


Figure 4.3: Functional Reach test performance by age and gender. Two way ANOVA showed a significant gender effect ($p \leq 0.05$) on reaching distance (cm).

compared to another recent Asian fall study (Chang et al., 2016; Hu et al., 2015; Jiang et al., 2015; Shi et al., 2014; Siong et al., 2016; Sohng et al., 2004). Therefore further analysis was carried out to identify the associated risk factors for falls among this cohort of Malaysian adults aged 50 years and above.

4.3.1 Regression analysis (univariate)

Based on the Chi Square and T-test (Table 4.9), a number of significant differences were identified between fallers and non fallers, with fallers having higher BMI, lower visual contrast sensitivity score, poorer balance (Step Test, increased sway and took longer time during to perform Step Quick Turn test), higher depression score, and slower walking speed. In addition, presence of back pain was significantly associated with falls status, χ^2 (1) = 3.56, p < 0.05, with those reporting back pain having almost three times the likelihood of having had a fall compared to those without back pain (O.R: 2.87).

4.3.2 Regression analysis (multivariate)

A correlation matrix of all balance and mobility measures is tabulated in Appendix 13. All dynamic balance measures for clinical and laboratory measures were significantly correlated. Multicollinearity is considered to be present if correlation exists greater than 0.7 (Dormann et al., 2013). Where multicollinearity was present, one of the pair of highly correlated measures was selected for inclusion in the regression analysis. In the present study, Timed and Up and Go test single task was found to be significantly correlated (with a correlation of greater than 0.7) with Timed Up and Go with dual task. For the multivariate regression analysis, the Timed and Go test with dual task was included in the analysis.

Multiple logistic regression identified that turning impairment was significantly associated with falls status and also absence of back pain and better vision contrast sensitivity were significant were (95% CI= 0.701, 0.890), were protective of falls, compared with impaired turning that increased risk of falling (Table 4.10). The multiple logistic regression model was statistically significant, χ^2 (8) = 36.26, p < 0.001. The Hosmer Lemeshow goodness of fit was not significant (p =0.843). The model explained 20.7% (Cox & Snell) to 29.1% of the variance in having a fall, and correctly classified 71.8% of fallers.

Table 4.9: Univariate analysis of balance performance and functional performance of participants according to fall status.

Characteristic	Non Faller (n=107) Mean (SD)	Faller (n= 49) Mean (SD)	*p* value
Body Mass Index, BMI (kg/ms^{-2})	27.2 (4.7)	28.6 (4.5)	0.071
Visual Contrast Sensitivity (MET Score)	21.2 (1.7)	20.5 (1.9)	0.028*
Clinical Measures of Balance			
Functional Reach Test	27.4 (6.5)	28.0 (5.7)	0.577
Step Test (worst leg)	16.5 (3.5)	14.9 (3.7)	0.012*
Timed Up and Go	10.1 (1.9)	10.6 (2.3)	0.177
Timed Up and Go with Dual Task	11.3 (2.5)	12.2 (3.6)	0.066
Five Times Sit to Stand Test	17.4 (5.9)	17.6 (5.4)	0.873
Laboratory measures			
mCTSIB - mean COG sway (deg/sec)	0.6 (0.4)	0.7 (0.4)	0.331
Limits of stability (LOS)			
- Movement Velocity (deg/sec)	3.1 (1.3)	2.9 (1.0)	0.223
- Reaction time(sec)	1.9 (1.2)	1.3 (1.3)	0.552
Walk across (WA)			
- Step width (cm)	17.7 (6.2)	17.8 (3.0)	0.853
- Speed (cm/ sec)	62.8 (15.0)	57.4 (16.8)	0.044*
Sit to stand Test-			
- Mean Rising Index (%of body weight)	16.2 (8.5)	13.8 (5.8)	0.073
- Mean COG sway (deg/sec)	2.8 (0.9)	2.8 (0.9)	0.801
Step Quick Turn - worst side			
-Turning sway (deg/sec)	49.0 (8.0)	52.2 (9.3)	0.028*
-Turning time (sec)	2.2 (0.8)	2.5 (0.8)	0.039*
Physical Activity and Psychological Measures			
Fall Efficacy Score (FES-I)	17.6 (6.1)	16.8 (6.4)	0.437
Depression (GDS15)	1.9	2.9	0.008**
Physical Activity Level (HAPAAS)	65.4	62.7	0.328

Note. *Statistically significant at $p < .05$, **Statistically significant at $p < .01$*.

Those who were identified as having imbalance during turning (turn sway or turn time or both outside of normal limits) were approximately five times more likely to have a fall compared to those who did not have turning impairment.

Table 4.10: Multiple logistic regression association with fall status**.**

Assessment	OR	95% CI		*p*
		LL	UL	
BMI (Kgms^{-2})	1.065	0.977	1.166	0.156
Visual Contrast Sensitivity (MET Score)	0.874	0.701	0.890	0.028*
Depression (GDS score)	1.149	0.938	1.408	0.179
Back pain (no)	0.214	0.077	0.596	0.003**
Timed Up and Go (dual task)	0.941	0.759	1.167	0.579
Walk across - Speed (cm/sec)	1.010	0.974	1.047	0.072
Step Test (worst leg)	0.888	0.845	1.070	0.607
Turning impairment (yes)#	4.824	1.707	12.839	0.003**

*Statistically significant at $p < .05$, **Statistically significant at $p < .01$.

Note. OR = odd ratio; CI = confidence interval; LL= lower limit; UL = upper limit; BMI = Body mass Index; MET = Melbourne Edge Test; #Turning impairment categorised – yes=turn sway or turn time or both outside of normal limits on the Neurocom™ Balance Master

4.4 Section IV: Identification of a suitable balance measurement suite for community dwelling Malaysian adults aged 50 years and above

The assessment suite used for this study has included a broad mix of assessment items assessing physical performance that can be associated with increased falls risk. A Principal Component Analysis (PCA) with varimax rotation of 14 of clinical and laboratory measures of balance and mobility was undertaken with data from 156 participants in order to determine an abbreviated suite of assessment items. An examination of the Kaiser-Meyer Olkin measure of sampling adequacy suggested that the sample was factorable (KMO = 0.70). The results of the varimax rotation of the solution are shown in Table 4.11. Five factors were extracted explaining 63.2% of total variance.

Table 4.11: Factor loading based on a principal components factor analysis with varimax rotation for 14 clinical and laboratory measures of balance and mobility (N=156)

Assessment	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Timed Up and Go with Dual Task	**-0.69**	**0.32**			
Step Test	**0.47**	**-0.37**			
Five Times Sit To Stand Test	**-0.75**				
Functional Reach test (cm)	**0.51**				**0.32**
Modified Clinical Test Sensory Interaction of Balance - Composite score mean COG sway (deg/sec)				**-0.74**	
Limits of Stability (LOS)Test					
- Reaction time (sec)			**-0.86**		
- Movement Velocity (deg/sec)			**0.84**		
- Endpoint excursion (%)			**0.55**	**0.65**	
- Directional control (%)				**0.73**	
SQT, worse side		**0.78**			
- Turn sway (deg/sec)					
- Turn Time (sec)		**0.86**			
Sit to Stand Test (STS) - Mean COG Sway Velocity (deg/sec)					**0.72**
Walk across (WA) test					
- Speed (cm/sec)	**0.58**				
- Step width (cm)					**0.77**
Eigenvalues	**3.64**	**1.56**	**1.32**	**1.28**	**1.06**
Percentage of total variance (%)	**25.97**	**11.14**	**9.41**	**9.15**	**7.56**
Number of test measures	**5**	**4**	**3**	**3**	**3**

Note: Factor loading < 0.3 are removed; mCTSIB = Modified Clinical Test of Sensory Interaction of Balance; LOS = Limits of Stability; WA = Walk across; STS = Sit to Stand; SQT = Step Quick Turn

Three of these factors appeared to group measures that could be clearly identified as sub-domains of balance / mobility, based on the measures loading most strongly onto the factors: (1) turning related tasks (factor 2), (2) leaning related tasks (factor 3), and (3) static stance tasks (factor 4). There are two main items that relate to turning ability, namely sway during turning and turning time that, strongly loaded onto factor labelled as "turning". Timed Up and Go (dual task) loaded weakly onto this factor. The time taken and movement velocity during the Limits of Stability test were strongly loaded onto the third factor, related to leaning ability. Furthermore, three items that loaded onto factor 4 relate to static stance balance, which accounted for 9.15% of the variance. The strongest loading variable on Factor 1 was the Five Times Sit to Stand test which included a combination of other physical performance tasks with moderate loading onto the factor, including walking, sit to stand, leaning and stepping components. This factor was therefore considered to be a dynamic leg strength factor. Factor 5 is difficult to interpret with two disparate measures of dynamic balance components loading strongly on to this factor. However, this factor only accounted for 7.56% of total variance. There were only four out of 70 correlations between measures and factors that were greater than 0.3 on factors other than the one they loaded most strongly on.

4.5 Discussion

4.5.1 Participant profile

The sample in this study were community dwelling adults aged 50 years and above, participating in University of the Third Age activities. Seventeen percent of the sample had three or more medical conditions, with most common medical conditions being diabetes mellitus, arthritis, followed by cardiac problems and back pain. Overall, the sample appeared to be a relatively well, and active cohort.

4.5.2 Falls prevalence and circumstances

Results from this study indicated the frequency of falls among people in Malaysia aged 50 years and older were common and comparable to previous western country studies among older people aged 65 years and above (Ambrose et al., 2013; Tinetti et al., 1988), and within the range of 6 to 35% reported by other Asian studies (Assantachai et al., 2003; Eun et al., 2015; Kwan et al., 2013a; Shin et al., 2009a). Of note, the majority of Asian studies in a review of studies reporting falls rates were substantially lower than those reported in the present study (Kwan et al., 2011a). Our study, similar to the majority of studies reported in the Kwan (2011) review used retrospective recall of falls in the past 12 months, which has been shown to under-estimate actual falls numbers by approximately 20% due to the possibility that participants may have forgotten to recall some of their fall experiences (Hill et al., 1999; Khalil et al., 2008). There are other factors that might also contribute to the lower falls rates reported in some of these previous studies, including not having a clear definition of fall and different interpretation of what a fall is between participants and researchers. Zecevic (2006) concluded that older people were prone to consider falls resulted most commonly from loss of balance, due to unintentional trips or slips, whereas healthcare professionals tend to consider falls as incidents with multiple contributory factors, and that can lead to injuries and illness. From a cultural perspective among some Asian populations, falls may be seen to be a disgraceful experience that they fear might be reported to other people (Shin et al., 2009a).

Results from this study found that the most frequent circumstances of falls were trips and slips, as well as loss of balance while walking at indoor and outdoor areas. This finding is similar to those identified in other Asian (Aoyagi et al., 1998; Assantachai et al., 2003; Jitapunkul et al., 1998a; Sohng et al., 2004) and non Asian studies (Hill et al., 1999; Painter et al., 2009). Participants reported high concern about falling when doing more challenging outdoors tasks which required more balance, such as going down a slope or reaching for a high object. There may be value in further exploring the link between outdoor activity and environment, and falls and falls efficacy. Of note, an important finding was that instability during turning is common and found to be one of the associated risk factors for falls among the studied population. This highlights that balance impairment especially during turning should received further attention for future fall intervention. Key elements relating to fall circumstances and activities can provide additional useful information to the risk factor assessment to inform the most appropriate falls prevention intervention to be recommended.

4.5.3 Effects of age and gender on balance performance

Interestingly, the current study found that those in the 50-59 year age group experienced more falls compared to older group. This finding is similar to a previous study which reported that 72% of those aged 50 years and above experienced more falls compared to other older age groups (Painter et al., 2009), and is also consistent with other Asian studies that reported the younger age groups experienced more falls

(Sohng et al., 2003). Possible explanations for this unexpected finding may be due to the recruitment which consisted of participants among U3A membership who were relatively healthy and active. One study of healthy older people in Australia found that almost 50% fell, and 10% suffered serious injuries from their falls (Hill et al., 1999). Furthermore, the younger group may be involved in more vigorous activity levels that could increase exposure to the risk of falls as compared to older aged groups that may be less active (Talbot et al., 2005).

4.5.4 Fall risk factors

In contrast to previous studies, there was no significant effect of age, gender and socio-demographic measures that contributed to fall status in the present study. Variables that were significantly associated with falls in univariate analyses were: step test, visual edge contrast sensitivity score, BMI, having back pain, depression level and turning performance during Step Quick Turn test. The measure with the strongest association with falls was instability during turning, with an odds ratio of 4.8, indicating a quadrupling of risk of falling relative to those without turning impairment. It is noteworthy that in the present study, the majority of participants have been classified of having at least mild turning instability based to the measures of the Neurocom™ Step Quick Turn test. The Step Quick Turn is one of the computerised protocols that provides an objective measure of turn sway and turn time (age and gender matched) relative to normal limits, and was found to be significantly associated with falls among the studied population. Turning performance has rarely been investigated as a measure of interest in studies investigating falls risk among older people. The findings from the present study highlight the importance of measuring turning performance when investigating falls risk. This is consistent with previous findings that reported that a fall during turning increases the risk of hip fracture 8-fold (Cumming & Klineberg, 1994). Therefore, possible interventions that aim to improve turning performance could be of benefit to the studied population, and others with increased risk of falling.

4.5.5 Assessment tools for balance performance

Based on the factor analysis, an abbreviated suite of measures is recommended as a minimum assessment suite when assessing physical and balance performance associated with falls risk for older people. These analyses showed that an abbreviated set of clinical measures of balance incorporating static and dynamic components could be recommended when assessing balance and mobility performance. Of note, the recommended tests focus on the clinical measures of balance, as availability of computerised balance machines such as the Neurocom™ in Malaysia is very limited and involves high cost. Based on the factor groupings and highest loading variables in the factor analysis results, it is recommended that Sit to Stand, Timed Up and Go test (dual task), Functional Reach test and Step Test are a useful abbreviated suite of clinical measures of balance and mobility when assessing populations such as those used in this study. Furthermore, these tools were commonly used for comprehensive assessment of balance and mobility previously (Hill & Schwarz, 2004).

4.6 Limitations of the study

This study has several limitations. The sample was a convenience volunteer sample, so there is a potential bias as it may not accurately represent the overall community dwelling population, especially comparing the current findings with other studies that use representative samples. Future research in Malaysia should consider use of representative sampling approaches to more accurately quantify the magnitude and implications of falls in this context. In addition, the age of 50 years and above was used in this study, because Malaysia is at a relatively early stage of population ageing relative to other countries such as Japan and Australia, which generally have used the age of 60 or 65 years and above as the criterion for older age.

4.7 Conclusion

The findings of this study provide insight into the circumstances, consequences and correlates of risk of falls in the Malaysian context, and highlight that falls are a common problem among active community dwelling Malaysians over the age of 50 years. Results also highlighted that one of the main factors differentiating fallers from non-fallers that has rarely been investigated in the past is unsteadiness during turning activities, and this risk factor warrants further investigation in terms of contributory factors and potential interventions. The study findings highlight the need for a strong focus on fall prevention in the primary healthcare system developing and implementing culturally appropriate and effective fall prevention programs in Malaysia.

CHAPTER 5

EFFECTIVENESS OF INDIVIDUALISED HOME BASED EXERCISE ON TURNING AND BALANCE PERFORMANCE AMONG ADULTS AGED > 50 YEARS: A RANDOMISED CONTROLLED TRIAL

5.1 Introduction

The current chapter provides detailed results for a randomised controlled trial study, that aimed to evaluate the effectiveness of a 16 week individualised home based exercise intervention in improving turning performance among adults aged >50 years with mild balance impairment during turning. This study was conducted based on the findings reported in a cross-sectional study (Chapter 4), which identified that more than half of the 135 participants had impaired turning performance (outside of age matched normal limits using the Step Quick Turn Test on the Neurocom™ Balance Master).

As discussed in the literature review (Chapter 2.5.3), older people with balance impairment and history of falls have been shown to have difficulties during turning (Dite & Temple, 2002b). Studies have reported that turning is an essential gait related activity involved in daily functional tasks. Sedgman et al. (1994) highlighted that turning is an important maneuver in daily activities, finding that 20% of steps involve turning. Another related study that evaluated turning in four community activities, including walking through a cafeteria, through a convenience store, and from a specific office to a car in the parking lot, reported that between 8-50% of steps involved turning maneuvers (Glaister et al., 2007). These findings affirm the importance of turning in daily ambulation. Turning has also been shown to be a more challenging maneuver compared to straight-line walking (Segal et al., 2008a) and the ability to maintain balance during turning is complex (Hase & Stein, 1999).

Furthermore, as compared to regular walking, falls while performing turning maneuvers are eight times more likely to result in hip fracture (Cumming, 1998), and have also been reported to be associated with greater risk of slip-related falls (Nagano et al., 2013).

Despite the significance of turning ability, and involvement of turning in the circumstances of many falls, to date few studies have investigated turning difficulties, and the effectiveness of exercise programs which include specific exercises to improve turning ability in people with identified turning impairment. Established exercise interventions such as the Otago Exercise Program (Campbell et al., 1997a) and the LiFE exercise program (Clemson et al., 2012) do integrate a small number of exercises that include turning related activities, but these are not routinely applied, nor is a turning task routinely used to determine problems with turning in order to tailor this type of exercise for the individual.

Therefore, the aims of this study were to evaluate the effectiveness of exercise that included a focus on turning performance, on the improvement of turning and other related measures of balance performance in people aged >50 years with impaired turning performance. It was hypothesised that the home based exercise intervention group would improve turning and balance performance relative to a control group over a 16 week study period.

5.2 Methods

Participants were recruited and randomised into control and intervention group. The details regarding inclusion and exclusion criteria, and recruitment and randomisation process have been described previously in Chapter 3.9 and has been published as a protocol (see Appendix 1). A study flow diagram is illustrated in Figure 5.1.

The assessment battery carried out for baseline and follow up are summarised in Table 3.1 (Chapter 3.4). The initial and follow up assessments were conducted at the Gerontology Laboratory, Institute of Gerontology, University Putra Malaysia at baseline and 16 weeks, by an assessor blind to group allocation (single blind study). The assessment took approximately 90 to 120 minutes.

The exercise intervention has been described in Chapter 3.12. In brief, the exercise program was based on the Otago Exercise Program, with two of the exercises selected for each intervention participant being additional exercises aiming to improve turning performance (Chapter 3.12). Participants were asked to exercise four times per week, and to also undertake a progressive walking program three times / week, for the 16 week period. Adherence to the exercise program was measured using a self report exercise diary (Chapter 3.12).

The primary outcome variables in this study were the turning performance measures from the Step Quick Turn assessment on the Neurocom™ Balance Master (turn sway and turn time), and the Timed Up and Go test (single and dual task). Secondary outcome variables were other balance and mobility measures - the Step Test, Functional Reach test and level of physical activity (Human Activity Profile Adjusted Activity Score (HAPAAS), and other variables from the Neurocom™ Balance Master tests: Walk Across (step width), Sit-To-Stand (degree of sway), and Limits of Stability (composite score of Maximum Excursion, Directional Control and Reaction Time). Adherence to the exercise program was also a secondary outcome measure.

Statistical analysis for this study is described in detail in Chapter 3.14, and reported briefly here. Data were analysed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp. in Armonk, NY). Baseline demographic and clinical characteristics were presented as a mean (SD), median, interquartile range, or n (%) for each group. Comparisons of the baseline characteristics of the participants in the two groups were analysed using Fisher’s exact test and Chi-square test for categorical data and independent Student’s t-test for continuous data. Data were inspected for normality of the distribution before use in analysis. All analyses were conducted using the intention to treat principle. Missing data due to an anticipated drop out rate of up to 20% were imputed using the last value carried forward (LOCF) method.

A two way between group analysis of variance (ANOVA) with repeated measures was applied to identify the effect of the exercise intervention on the turning and balance measures. Any baseline differences between groups were included as covariates in the analysis. Adherence with the exercise program was divided into high adherence (exercise four times or more each week) or low adherence (three or less times exercise each week). A change score in primary outcome measures (turn sway and turn time on Step Quick turn Test) at baseline and re assessment for high and low adherence group were calculated. Independent t-tests were applied to identify if the mean change in turn sway and turn time score of the Step Quick Turn test differed between high and low adherence groups.

Effect sizes (mean change / pooled SD) were calculated for all measures for the intervention group.

This study has been accepted for publication in Ashari et al. (2016) (see Appendix 14 for a copy of this publication).

5.3 Results

A total of 110 potential participants aged 50 years and above volunteered to participate in the study. After screening for inclusion criteria, 42 participants were not randomised due to having normal turning performance (sway turn (deg/s) or turn time (s) within the normative range (based on age and gender) of the Step Quick Turn test, provided by the Neurocom™ Balance Master long force platform.

Sixty eight participants who had abnormal turning performance and completed the screening for inclusion criteria, were randomised to either the intervention group or the control group based on a concealed randomisation procedure as detailed in Chapter 3.11. There were 34 participants assigned to the intervention and 34 to the control group. The recruitment and randomisation of the participants through the study is shown in Figure 5.1. At the completion of the study, 63 participants (31 in the intervention group and 32 in the control group) completed the 16 weeks follow up assessment.

5.3.1 Participant characteristics

Characteristics of the study participants are shown in Table 5.1. The mean age of participants was 63.7 (±6.4SD, Min 50, Max 79) years, 57.4% were females; 70.6% were Malays and 29.4% others (primarily Chinese and Indian), and 70.6% were retirees, and participants were predominantly living with a spouse (86.8%). At the initial assessment, 14 participants (20.6%) reported one or more falls in the previous 12 months and the average fall risk score using the FROP-Com was 5 (low risk). Participants had a median of one medical condition, with the most common medical conditions reported being back pain (20.6%), dizziness (16.2%) and diabetes (16.2%). Most of the participants indicated high concern about falling, with the mean score for the Short Falls Efficacy Scale International (FES-I) assessment being 19.1±6.6. Participants had little symptoms of depression based on the Geriatric Depression Scale score. More than half of participants (64.7%) were classified as moderately active based on the Human Activity Profile Adjusted Activity Score (<74).

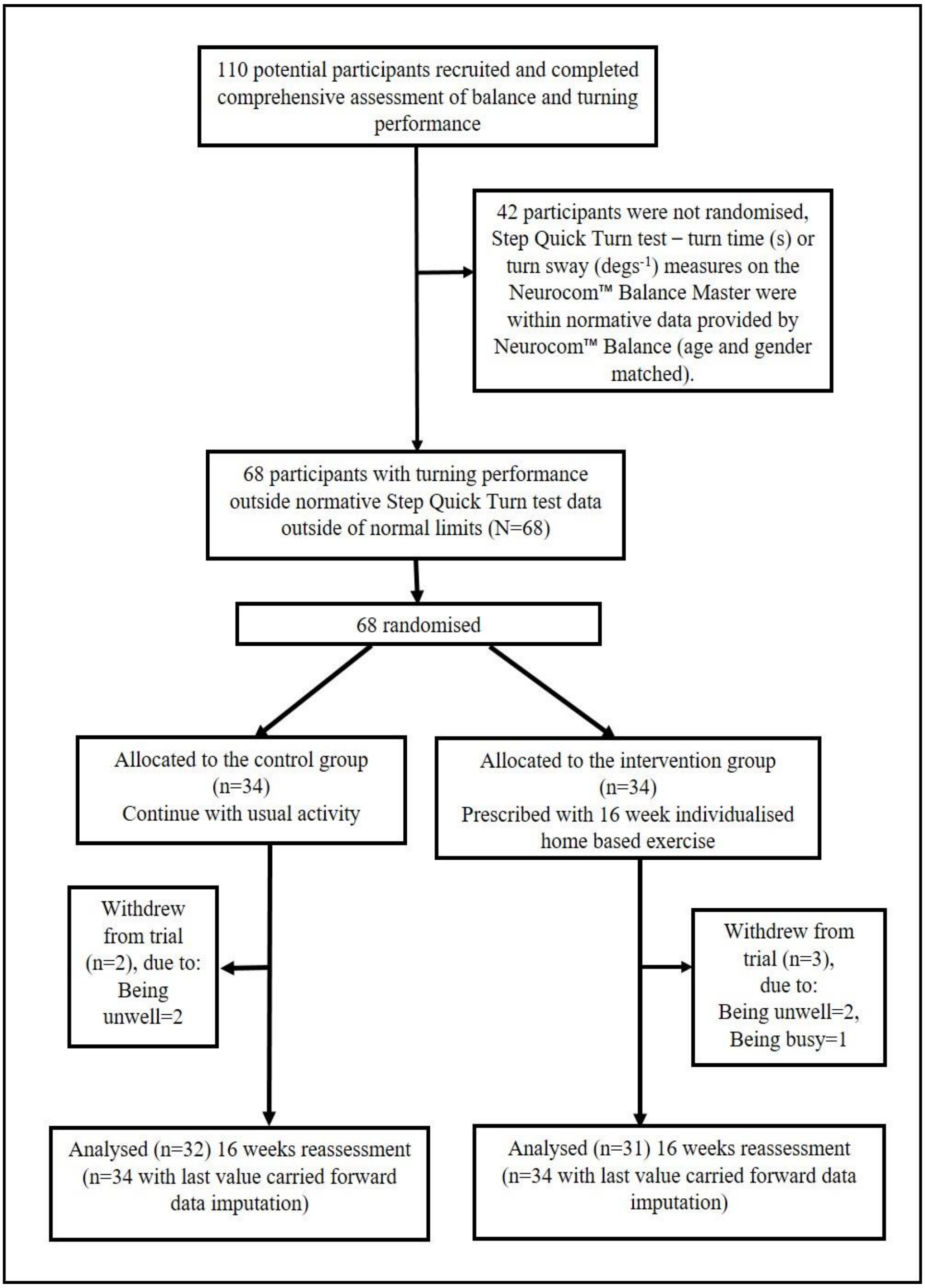


Figure 5.1: Diagram of participant flow through the trial

5.3.2 Baseline assessment of turning, balance and physical performance of participants

Overall, the baseline characteristics (Table 5.1), balance and functional ability scores (Table 5.2) were similar between the intervention and control group. The only significant difference was that there were more self-reported fallers in the past 12 months allocated to the intervention group relative to the control group (29% vs 12%).

5.3.3 Changes in turning and balance related measures over 16 week individualised Home based exercise (HBE) intervention

In total, 63 participants (31 in the intervention group and 32 in the control group) completed the 16 weeks follow up assessment. Participants withdrew from the study primarily due to being unwell (n=2), relocation (n=1), or being too busy (n=2).

Participants in the intervention group were prescribed on average eight exercises, consisting of general warm-up exercises, balance and strengthening exercises, including two exercises aiming to improve turning performance, and a tailored graduated walking program. Overall, participants took approximately between 20 to 30 minutes to perform the exercises and were asked to undertake these exercises four times each week. Participants in the exercise intervention were also asked to walk three times per week for a prescribed time that was gradually increased during the 16 weeks. Table 5.3 reports the most commonly prescribed exercises to improve turning ability. For the turning component of the exercise program, the most frequently prescribed turning exercise was the figure of 8 walk and step turn (see Table 3.2, Section 3.12 for details of all exercises used). The turning exercises were progressed initially by increasing the number of repetitions, and at later stages by changing the turning exercise. Participants were asked at each visit if they had experienced any adverse events since the preceding visit. Timing and nature of the adverse event were noted to determine if the adverse event might be related to the exercise (eg muscle or joint pain shortly after an exercise session). Participants were asked at each visit if they had experienced any adverse events since the preceding visit. Timing and nature of the adverse event were noted to determine if the adverse event might be related to the exercise (eg muscle or joint pain shortly after an exercise session). There were no adverse events attributable to the exercise intervention observed during the intervention period. Analyses for the study outcomes were adjusted for the baseline difference in falls by including number of falls in the previous

Table 5.1: Participant characteristics

Characteristic	Intervention (n=34)	Control (n=34)	Total (n=68)	p value
Age (years), mean (SD, min-max),	62.4 (6.6, 50-79)	64.8 (6.1, 54-76)	63.7 (6.4, 50-79)	0.113
Women, n (%)	19 (55.9)	20 (58.8)	39 (57.4)	0.806
Malay, n (%)[a]	24 (70.6)	24 (70.6)	48 (70.6)	0.793
Living with spouse, n (%)	28 (82.4)	31 (91.2)	59 (86.8)	0.562
Retirees, n (%)	24 (70.6)	24 (70.6)	48 (70.6)	0.875
BMI (Kg/ms^2), mean (SD, min-max)	26.4 (3.8)	25.9 (3.8)	26.1 (3.8)	0.558
Height (cm), mean (SD, min-max)	157.9 (7.9, 142-175)	156.5 (7.3, 145-174)	157.3 (7.7, 142-175)	0.473
Had a fall in last 12 months, n (%)	10 (29.4)	4 (11.8)	14 (20.6)	0.039*
Risk of Fall Score (FROP-Com), median (25th and 75th percentiles)	5 (1-7)	5 (1-8)	5 (1-8)	0.807
Number of medical conditions, median (25th and 75thpercentiles)	1 (0-3)	1 (0-1)	1 (0-1)	0.865
Number of medications, median (25th and 75th percentiles)	1 (0-2)	1 (0-1)	1 (0-3)	0.467
Falls Efficacy Scale (FES-I score-7 items), mean (SD, min-max)	19.9 (6.9, 7-28)	19.9 (6.9, 7-28)	19.1 (6.6, 7-28)	0.184
Depression (GDS Score- 15 items), mean (SD, min-max)	0.88 (1.70,)	1.21 (1.53)	1.04 (1.62, 0-6)	0.423
Human Activity Profile Adjusted Activity Score (HAPAAS), mean (SD, min-max)	72.9 (5.9, 61-85)	70.5 (7.5, 56-86)	71.7 (6.8, 56-86)	0.147

Note: Other ethnicities included Chinese and Indian, BMI = Body Mass Index; FROP-Com = Fall Risk of Older People in Community; FES-I = Falls Efficacy Scale International.

Table 5.2: Balance performance on clinical and laboratory measures at baseline

Measures	Intervention (n=34)	Control (n=34)	p value*
	Mean (SD, min-max)	Mean (SD, min-max)	
Laboratory measures of balance			
- SQT, worse side turn sway (deg / sec)[#]	50.30 (10.17, 23.20-78.30)	54.12 (10.89, 30.40-80.60)	0.141
- SQT, worse side turn time (sec) [#]	2.33 (0.51, 1.46-3.31)	2.46 (0.51, 1.39-3.45)	0.308
- mCTSIB, Composite sway (deg /sec)	0.50 (0.23, 0.13-1.05)	0.47 (0.16, 0.25-0.95)	0.896
- LOS, reaction time (sec)	1.20 (0.25, 0.74-1.83)	1.32 (0.23, 0.91-1.92)	0.426
- LOS, directional control (deg /sec)	73.68 (8.24, 55-88)	75.31 (6.75, 60-86)	0.376
- LOS, maximum excursion composite score (% LOS)	84.97 (8.80, 71-104)	81.41 (11.42, 64-101)	0.155
- WA, step width (cm)	16.60 (3.45, 7.9-23.8)	16.74 (3.05, 11.5-24.4)	0.827
- STS, COG sway (deg /secs)	2.51 (0.82, 1.0-4.3)	2.48 (0.98, 0.9-5.7)	0.894
Clinical measures			
- Timed Up and Go (sec)	10.4 (1.41, 8-13)	10.7 (1.50, 8-14)	0.372
- Timed Up and Go with dual Task (sec)	15.0 (2.47, 10-20)	15.1 (2.89, 9-22)	0.859
- Five Timed Sit-to- Stand Test (sec)	12.6 (1.60, 9-16)	12.2 (1.88, 9-15)	0.826
- Functional Reach Test (cm)	29.7 (4.65, 20-39)	28.1 (4.93, 15-39)	0.365
- Step Test, worse leg stepping (number of steps/ 15 sec)	13.8 (2.5, 9-19)	13.7 (2.4, 8-19)	0.925

Note. SQT = Step Quick Turn; mCTSIB=modified Clinical Test of Sensory Interaction of Balance; LOS = Limit of Stability; WA = Walk Across; STS = Sit To Stand Test; COG = centre of gravity.

[#] The turn task was assessed turning to the left, and also turning to the right. The worst performance from these two tasks was the score reported.

12 months as a covariate. Tables 5.4 and 5.5 compare participant performance from baseline to the 16 weeks reassessment between the intervention and control group. There was a significant group by time effect for both turning measures (SQT) on the Neurocom™ Balance Master long force platform: for turn sway, $F(1,65) = 8.070$, $p=0.006$, and turn time $F(1,65) = 8.216$, $p=0.006$, with significantly better performance over time by the intervention group relative to the control group. There were also significant group by time effects for a several of the secondary measures: composite static stance sway mCTSIB, $F(1,65) = 10.491$, $p=0.002$, Timed Up and Go (TUG) single task, $F(1,65) = 6.647$, $p=0.012$, and TUG dual task, $F(1,65) = 8.301$, $p=0.005$. For all of these measures, the intervention group had significant improvement over time relative to the control group (Tables 5.4 and Table 5.5). Effect sizes were calculated for change in intervention group participants for all measures. Of the measures that improved significantly with the intervention, effect sizes ranged from 0.47 (medium effect) for Timed Up and Go test to 1.09 (large effect) for the Modified Clinical Test of Sensory Interaction of Balance (composite sway).

Although the study was not powered to detect a difference in falls or fallers between the two groups over the 16 weeks, information regarding falls could provide data to inform future sample size estimation for this outcome. In the present study, data on falls was collected through the follow up phone call for both groups (control and intervention), four phone calls which occurred at 4, 8, 12, and 16 weeks. Over the 16 weeks, a total of five participants (7.4%) fell. Two participants in the intervention group (5.8%) fell during the 16 weeks, compared with three (8.8%) in the control group. The most common cause of falls were a slip on the floor during rushing while walking (three participants) and two participants reported tripping on a curb during walking in community areas. No falls were related to turning activities. All participants who fell reported experiencing minor injuries such as grazes and bruises, which did not require medical treatment.

5.3.4 Adherence level to the individualised balance exercise program

The level of adherence to the study intervention was determined based on exercise participation as recorded by participants in the exercise diary provided at the initial visit when intervention participants received details of their exercise program. No compliance issues with completion of the exercise diary were reported. High exercise adherence was classified as performing the prescribed exercises four or more times each week. Low exercise adherence was classified as performing the exercises three

Table 5.3: Turning exercises for consideration for inclusion in the prescribed exercise program at each laboratory visit. The number in the table for each visit refers to the number of participants prescribed each exercise.

Prescribed Turning Component	Description	Initial visit	Visit 1 Week 3	Visit 2 Week 6	Visit 3 Week 9
90 degree turns on the spot (up to 20 repetitions)	Participant stands upright and feet shoulder width apart. Then, turns left foot 90 degrees to the left, followed by the right foot. After that turn right back to initial position. Repeat this manoeuvre in the opposite direction.	20			
Figure 8 walk (up to twice in each direction)	Participant walks in figure 8 motion between two cones (or similar marker) at usual pace.	34	33	32	31
Step across body (10 repetitions each leg)	Participant stands upright with feet 15 cm apart. Step the right leg across in front of left leg to land about 15cm outside the position of the left foot, balance, then step back to the starting position. Repeat with the left leg stepping.	14	33		
Braiding (up to 15 steps and turn)	Participant stands up tall. Then, move to side, cross right leg in front of left leg, bring left leg out to side, then cross right leg behind left leg and so on. Repeat along a corridor / sturdy bench. Repeat toward opposite direction			32	31

Table 5.4: Laboratory measures of balances performance outcome measures at baseline and 16 weeks follow up between the intervention and control group. Analyses are adjusted for baseline difference in number of falls.

Measures	Intervention (n=34)		Control (n=34)		Mean difference between group (95% CI)	Effect size	p value#
	Baseline Mean (SD)	Follow-up Mean (SD)	Baseline Mean (SD)	Follow-up Mean (SD)			
Laboratory measures of balance							
SQT, worse side							
- turn sway (deg/sec)	50.30 (10.17)	41.72 (12.01)	54.12 (10.89)	52.74 (10.83)	-7.58 (-11.71 to -0.44)	0.78	0.006
- turn time (sec)	2.33 (0.51)	1.81 (0.72)	2.46 (0.51)	2.34 (0.55)	-0.33 (-0.58 to -0.08)	0.80	0.006
mCTSIB,							
Composite sway (deg/sec)	0.50 (0.23)	0.31 (0.12)	0.47 (0.16)	0.53 (0.30)	-0.11 (-0.18 to -0.03)	1.09	0.002
LOS							
- reaction time, (sec)	1.20 (0.25)	1.13 (0.26)	1.32 (0.23)	1.29 (0.32)	-0.14 (-0.25 to -0.02)	0.27	0.529
- directional control, (deg/sec)	73.68 (8.24)	73.50 (9.60)	75.31 (6.751)	72.92 (9.47)	-0.29 (-2.40 to 1.81)	0.02	0.154
- maximum excursion composite score (% LOS)	84.97 (8.8)	86.17 (7.87)	81.41 (11.42)	80.80 (9.50)	1.27 (-0.61 to 3.166)	0.14	0.444
WA							
- step width (cm)	16.60 (3.45)	16.45 (3.47)	16.74 (3.05)	16.87 (3.75)	-0.29 (-1.84 to 1.26)	0.04	0.832
STS							
- COG sway (deg/sec)	2.51 (0.82)	2.69 (0.90)	2.48 (0.98)	2.95 (1.07)	-0.11 (-0.49 to 0.27)	0.23	0.211

Note. SQT=Step Quick Turn; mCTSIB=modified Clinical Test of Sensory Interaction of Balance; LOS=Limit of Stability; WA=Walk Across; STS=Sit To Stand Test; COG=centre of gravity; #=p value relates to the group by time interaction effect for the Two Way between group ANOVA.

Table 5.5: Physical activity, clinical balance and mobility performance outcome measures at baseline and follow up between groups. Analyses are adjusted for baseline difference in number of falls.

Measures	Intervention (n=34)		Control (n=34)		Mean difference between group (95% CI)	Effect size	p value#
	Baseline	Follow-up	Baseline	Follow-up			
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)			
Clinical measures							
Timed up and Go (sec)	10.4 (1.4)	9.8 (1.2)	10.7 (1.6)	10.7 (1.7)	0.31 (0.10 to 0.52)	0.47	0.012
Timed up and Go with dual Task (sec)	15.0 (2.5)	13.8 (2.3)	15.1 (2.7)	15.3 (2.9)	0.49 (0.03 to 0.94)	0.50	0.005
Five Timed Sit-to-Stand Test (sec)	12.6 (1.6)	11.9 (1.7)	12.4 (1.7)	12.2 (1.9)	0.40 (-0.06 to 0.85)	0.38	0.399
Functional Reach Test (cm)	29.7 (4.7)	30.1 (4.4)	27.2 (6.0)	28.1 (4.9)	-0.60 (-1.88 to 0.60)	0.09	0.873
Step test, worse leg stepping (number of step/ 15 sec)	13.8 (2.5)	14.7 (2.4)	13.7 (2.7)	14.1 (2.4)	0.69 (-1.14 to -0.24)	0.37	0.230
Human Activity Profile Adjusted Activity Score (HAPAAS), mean (SD, min-max)	72.9 (5.9)	75.3 (6.4)	70.5 (7.5)	73.1 (7.5)	2.28 (0.81 to 3.75)	0.39	0.635

Note. # = p value relates to the group by time interaction effect for the two way between group ANOVA.

or less times each week. Twenty one of the 31 participants in the intervention group who completed the follow up assessment (67.7%) reported exercising four times or more each week, and the remaining 10 participants exercised three times per week.

A subsequent analysis was carried out to identify whether there was any effect of higher exercise adherence on the turn outcomes: (1) turn sway (lower value indicates better balance during turning), and (2) turn time (shorter time indicated better turning performance) on the Step Quick Turn test on the Neurocom™ Balance Master. An independent samples t- test was used to compare the turn sway (deg/sec) and turn time (sec) difference assessed at baseline and after 16 weeks intervention for high and low adherence groups. Neither Shapiro Wilk statistic was significant, indicating that the assumption of normality was not violated.

Results are shown in Figure 5.2 and Figure 5.3. The t- test was statistically significant, with the high adherence group (M=14.70, SD= 10.14) achieving greater reduction in turn sway with the mean difference -12.07 degree/sec higher, 95% CI (-18.47, -5.67), than the low adherence group (M=2.63, SD= 7.02), t (32) =-3.850, p=0.001. No significant mean difference was seen for turn time between these two groups (p=0.062). These results highlight that participants with high adherence had a significantly better improvement on turning sway performance than those with lower adherence.

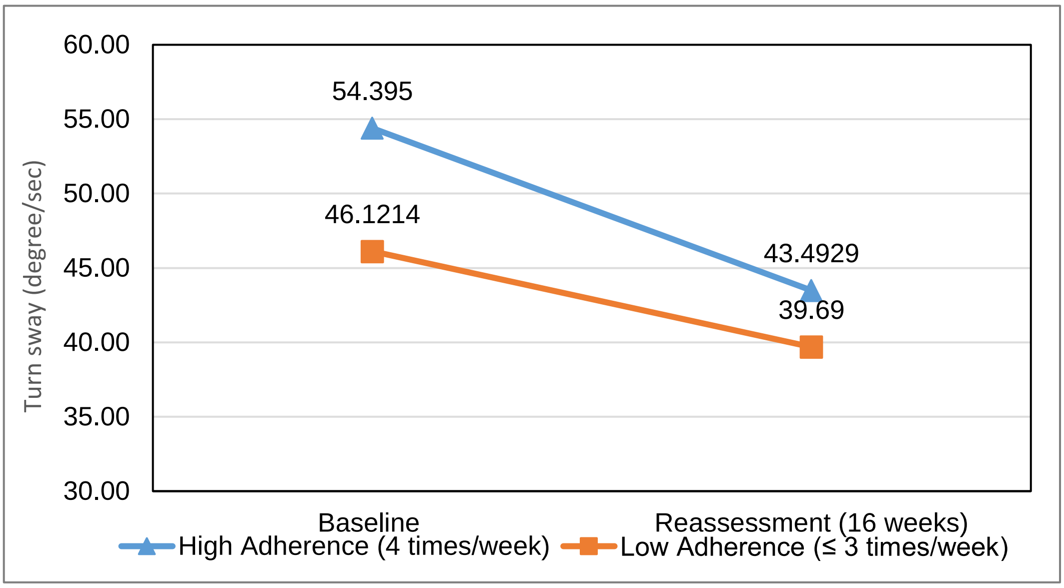


Figure 5.2: Mean change in turning performance (turn sway) at baseline and reassessment by adherence

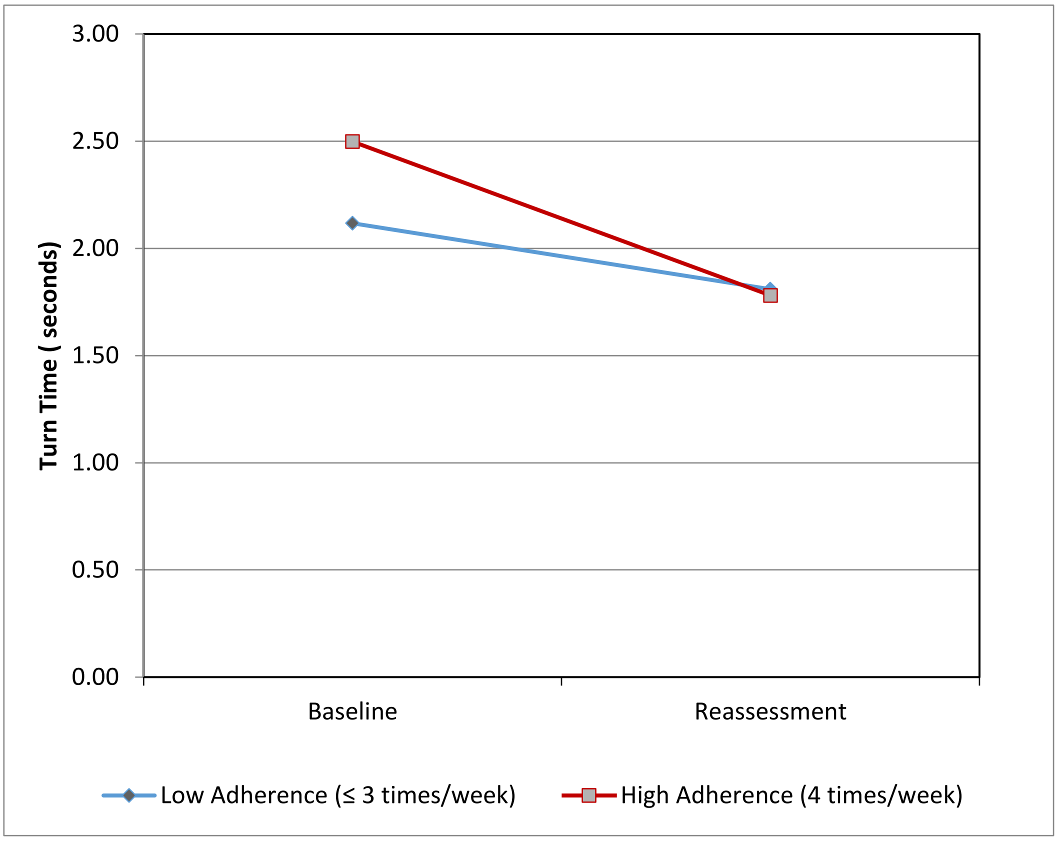


Figure 5.3: Mean change in turning performance (turn time) at baseline and reassessment by adherence level.

5.4 Discussion

The results of this study showed that 16 weeks of individualised home based exercise that included exercises targeting improved turning performance did significantly improve turning performance as reflected in decreased degree of sway and turn time, and improved Timed Up and Go, in a sample of adults aged > 50 years with reduced turning performance at study commencement. To our knowledge, this is the first study that has targeted a sample of adults aged > 50 years with impaired turning performance, and incorporated specific exercises aiming to improve turning performance into a home exercise program.

A number of studies have demonstrated improvement in general balance and mobility, and reduced falls with home exercise programs such as the Otago Exercise Program (Gillespie et al., 2012). Rarely have these studies utilised turning performance as an outcome measure. However, in another study of older people with mild balance impairment (performance on a number of measures was similar to the sample in our study), Yang et al reported no improvement in the Step Quick Turn measures using the Neurocom™ Balance Master long force platform after a six month home exercise program. The study by Yang and colleagues utilised the Otago Exercise Program and another commercially available program (Yang et al., 2012), but did not include a focus in the exercise program on including exercises to improve turning performance for all participants.

Turning is a commonly performed task in daily life (Glaister et al., 2007; Sedgman et al., 1994), is a complex task requiring interplay between sensory and motor systems, and can be involved in falls circumstances for older people (Wright et al., 2012). Given these factors, turning performance is an important construct to be considered for both assessment and targeted intervention by health professionals. In our study, the selection of participants for the exercise program required identification of impaired turning performance on an expensive force platform, which is not available in most clinical settings. Turning performance has been assessed using different forms of gait analysis in a number of studies and different clinical samples, including in older people with neurological conditions such as Parkinson's disease (Chen et al., 2014). However, in clinical settings, more simple clinical measures, without use of expensive analysis systems are needed.

A 10 item scale has been reported as a clinical tool to measure turning performance (Dite & Temple, 2002a). This test consists of nine movement items based on observation of the ability to perform a 180 degree turn. Three items on this scale were (i) total turn score, (ii) turn step number, and (iii) turn time; and two were dichotomous items rated as yes or no on the ability to (i) initiate, and (ii) execute the turn. This scale to measure turning was found to be both a reliable and valid clinical measure of turning while walking for older adults, discriminated between healthy and impaired older adults, and had good sensitivity for identifying multiple fallers (Dite & Temple, 2002a). Future research should investigate whether measurement of turning performance using this tool can classify turning impairment to a similar level to that achieved by the Neurocom™ Balance Master in our study.

Few previous studies have investigated interventions to improve turning performance in older people or others at risk of falls. One study utilised a novel approach of training turning ability on a specially designed treadmill apparatus (Chen et al., 2014) and reported a significant improvement for turning speed in chronic stroke patients. A limitation of this type of approach though, is that the apparatus is relatively expensive, and only one person can be trained at a time. In contrast, the home based intervention approach used in this study can be safely and effectively implemented with relatively little health practitioner involvement.

In addition, this study also investigated the important role of adherence to the home based exercise program. Findings suggested that adherence rate and level of support plays an importance role to optimise the efficacy of the individualised home exercise program in improving turning performance in adults aged > 50 years old. Even though there remains a lack of consensus in the research literature about the standard cut-off point for sufficient adherence, generally a minimum of 70% adherence is regularly applied (Geraedts et al. 2014). Therefore, in the current study, exercise adherence of 3 times per week (which was classified as low adherence), still demonstrates a fairly good level of exercise participation. The dropout rate in our study was relatively low (seven percent), and the proportion of participants achieving full adherence was relatively high compared to many other exercise and fall prevention studies (Nyman & Victor, 2011). Possible factors contributing to these high retention and low dropout rates may be the frequent follow up phone calls between visits, and the reasonably good functional status of the sample.

The study had several limitations. These included that the participants were recruited from a single organisation on a volunteer basis, which may restrict the generalizability to the wider population. In addition, the data used to define cut offs in the turning task on the Neurocom™ Balance Master were based on an American sample, and it is possible that cut offs may be slightly different in an Asian sample such as was used in our study. However, data is compared to age and height referenced norms within the system. In addition, there may have been value in including executive function assessment in this sample, given the association between balance impairment and executive function (Muir et al., 2013). A further limitation was that the study used the Step Quick Turn assessment on a computerized force platform using a standard protocol that may constrain the normal variability in turning seen in “real life”. Future studies may consider evaluating the usefulness of simple clinical measures to quantify turning impairment, include equal contact time between participants and the researchers for both groups, and should utilise a larger sample and be sufficiently powered to evaluate the effect of this type of intervention on reducing falls. Future studies should include longer term follow up to evaluate sustainability of exercise benefits after completion of the formal exercise program, and may explore associations between turning performance and biomechanical markers of poor balance. A limitation of the method of reporting adherence in this study was the participant's adherence was based on whether or not exercising occurred on each day, not how many exercises were performed each day. Future studies should also include data on the proportion of recommended exercise performed/ session.

5.5 Conclusion

In conclusion, this study has demonstrated that a home based exercise program incorporating exercises to improve turning performance resulted in improved turning performance in a sample with pre-existing impaired turning performance. Clinicians should consider including assessment of turning ability in their assessment of older people with falls risk, and utilise exercises challenging stability during turning in a rehabilitation plan for those identified with turning impairment.

CHAPTER 6
GENERAL DISCUSSION

6.0 Introduction

This chapter discusses the overall findings from the studies reported in this thesis, and identifies the clinical implications of these findings, the strengths and limitations of the studies, and includes recommendations for potential future research directions.

6.1 Major findings on prevalence of falls and fall risk assessment among community dwelling Malaysians aged 50 years and above

The aims of this thesis were to provide baseline information of prevalence and circumstances, and contributory risk factors associated with falls (using a detailed fall risk assessment), and to evaluate outcomes associated with a novel exercise intervention in improving balance impairment (in particular, focussing on turning performance) among community dwelling Malaysian adults aged 50 years and above.

Over the last three decades, a substantial number of epidemiological studies of falls and associated risk factors been conducted. The majority of this research has occurred among western populations, but there has been a small amount of recent research focus on these topics in Asian populations. It has become apparent that there is a crucial need to identify the magnitude of falls and contributory risk factors in different populations, given the substantial individual, environmental, societal, cultural, and health system differences between countries. Previous research has highlighted that several factors such as differences in falls definition applied in the falls studies, methodologies, environment and cultural perspectives in different populations and regions have contributed to the variations of falls rates between countries, with lower rates commonly reported in Asian countries (Dsouza et al., 2014; Hua et al., 2007; Krishnaswamy & Usha, 2006; Kwan et al., 2011a).

At the time the research for this thesis commenced (in 2011), there was limited evidence of detailed assessment outcomes relating to fall risk factors, and also no effective fall prevention interventions (randomised controlled trials) had been conducted among Malaysian older adults living in the community. Additionally, there is increasing evidence that management strategies should be designed within the context of local need, be culturally appropriate (Organisation, 2007) and in parallel to the relevant primary and public health care systems (Hamid et al., 2012), in the case of this research – in Malaysia.

The results of the cross-sectional prevalence study (n=156) of falls, circumstances and associated risk factors for falls among Malaysian community dwelling adults aged 50 years and above is reported in detail in Chapter 4. Retrospective recall of falls in the previous 12 months indicated that falls are a common problem for the Malaysian older population. The prevalence rate in the studied sample was 31%, which is consistent with most western studies (Blake et al., 1988; Cesari et al., 2002; Holt et al., 2011; Milat et al., 2011; Tinetti & Williams, 1998) and considerably higher compared to previous falls studies reported from neighbouring areas of the region such as Thailand, Taiwan, Korea, Hong Kong and Singapore (Chan et al., 1997; Chang et al., 2010; Chu et al., 2005; Kwan et al., 2011a; Shin et al., 2009a; Sohng et al., 2003). Thus, this study provided new insights about falls among community dwelling adults aged 50 years and above in the Malaysian context.

Factors such as understanding the meaning of falls, methodologies applied in the previous studies as well as cultural perspectives might be factors contributing to the variation in falls rate between Asian studies. Most of the studies conducted in the Asian region are focused on Chinese populations, whereas the majority of the participants in the present study were Malays (with some Indian and Chinese participants). These ethnic differences between samples could be an important factor, for example, a relevant falls study in Singapore has shown that Malays had a higher rate of falls compare to the Chinese group of participants (Chan et al., 1997). Another contributory factor to these observed differences may be related to some Chinese populations viewing that a fall is a disgraceful event, and as such, they are less willing to share with others about falls (Shin et al., 2009a). Furthermore, Chinese populations have been reported to have higher concern of falls compared to western populations (Kwan et al., 2013a). Because of the ethnic and cultural diversity among the Malaysian population, there is justification for greater understanding and further investigation on behavioural, life style, and health factors related to falls across and between ethnic groups to build on this research.

Most commonly identified falls risk factors in this sample of community dwelling Malaysians aged over 50 years were depression, back pain, reduced contrast sensitivity, and turning impairment. The majority of the risk factors identified were similar to those reported in other Asian and non-Asian counties. There were however, some differences, for example, in contrast to previous reports (Ambrose et al., 2013; Assantachai et al., 2003; Chang & Do, 2015), socio demographic variables such as age and gender were not significant risk factors for falls in the present study. One important and novel finding from the comprehensive balance assessment suite using a force platform was that impaired turning performance differentiated fallers from non-fallers. While turning is an activity that has been implicated in some falls, it is rarely assessed or focussed on in terms of intervention.

In contrast to most previous research, this study also indicated that falls were prevalent among the younger-old age group. Those in the group aged 50-59 years experienced more falls compared to the older age group. A small number of previous studies have reported a similar finding, for example Painter et al., 2009 found that 72% of total falls occurred among those aged 50 to 60 than those in older age groups. However, most of the participants aged 50 to 60 in the study by Painter and colleagues were reported to be homebound and less active due to disability resulting from medical conditions. This finding is also consistent with another Asian study that reported the younger age groups experienced more falls (Sohng et al., 2003). A possible explanation for this increased risk with younger-old participants is the higher level of physical activities, and engagement in more vigorous activities compared to older groups (Talbot et al., 2005), a finding also seen in the current research study. This may increase exposure to falls risk, as detailed in Chapter 4.1.3. Moreover, falls during vigorous activities could increase the momentum of the body at the time of impact in a fall, and result in greater severity of fall related injuries (Hill et al., 1999), and younger age groups have been reported to have a higher proportion of injurious falls than older age groups (Hong et al., 2010).

The present study also demonstrated that a detailed falls risk assessment battery supported by a range of physical, health status, psychological, and a combination of clinical and laboratory measures of balance provided valuable information about risk factors to inform suitable fall prevention interventions which have rarely been investigated among Malaysia's older population (Rizawati & Mas Ayu, 2012; Sazlina et al., 2008). Additionally, factor analysis was used to define an abbreviated suite of measures recommended as a minimum test battery when assessing physical and balance performance associated with falls risk for older people in Malaysia. This set of clinical physical performance and balance measures incorporating static and dynamic components are recommended when assessing balance and mobility performance. Further research could be undertaken to establish normative data for some of these measures where norms have not been established in Asian countries.

Similar to the present study, trips and slips while walking or turning have been shown to be the most prevalent causes for falls (Glaister et al., 2007; Yamaguchi et al., 2012). This, combined with the identified turning stability impairment in the present study highlights that balance impairment in turning is a common problem, with those who had balance impairment in turning having three times the risk of having a fall. This finding has provided new information in falls research and has important clinical implications due to the importance of turning in daily tasks (Dite & Temple, 2002a; Glaister et al., 2007). Given the importance of turning and the strong association in predisposing older people to falls and associated injuries, an appropriate exercise intervention which aims to address the specific balance impairment of turning warrants investigation.

6.2 Effectiveness of an individualised home based exercise intervention with a focus on turning performance

A single blind randomised controlled trial was conducted to identify the effectiveness of a home based exercise program that included a focus on turning performance, on improving balance among community dwelling adults aged 50 years and above who were assessed as having impaired turning performance (Chapter 5). Primary findings demonstrated that the 16 weeks individualised home based exercise intervention was effective in improving balance and mobility impairment, including turning performance, among those with turning balance impairment. Significantly improved turning performance as reflected in decreased degree of sway and turn time, and improved Timed Up and Go were achieved, in a sample of 68 adults aged > 50 years (34 in the intervention and 34 in the control group). From a physiotherapy perspective, this study has value added to the role of home based exercise intervention programs by incorporating turning exercises, which have rarely been investigated to improve turning performance previously.

Furthermore, this type of home based exercise intervention appears to be a suitable intervention, as it has been well accepted with diverse samples of older adults

(Rejeski et al., 2013; Rejeski et al., 2007). The results of this study highlight that this type of exercise intervention is also acceptable in the Malaysian context. The adherence to the intervention program in the current study participants was relatively high compared to many other exercise and fall prevention studies (Nyman & Victor, 2011; Nyman & Victor, 2012). A possible explanation for the high adherence rate observed in this study may be due to the better physical and functional status, and higher socio economic status of the sample (Picorelli et al., 2014). Further, the study results suggested that the level of support by the researcher may play an important role in the relatively high adherence rate, and may also be a factor enhancing the likelihood of the efficacy of the individualised home exercise program in improving turning performance in adults aged more than 50 years of age.

6.3 Clinical implications

The present studies demonstrate that falls are a common health problem among community dwelling Malaysians aged 50 years and above, with the proportion of fallers comparable to most western studies. Given this high prevalence, and the very limited focus on falls prevention in Malaysia currently, there is a need for developing programs to address falls risk across various avenues to ensure wide reach to the growing ageing population in Malaysia. This may involve working through doctor's clinics, out-patient services, community and health promotion services, and may also involve education and screening approaches through groups such as that involved as participants in the studies for this thesis – people involved in University of the Third Age. In addition, falls were most prevalent among the younger-old participants. Therefore, a routine risk assessment including physical and clinical assessment of balance should be carried out for people aged 50 years and above in Malaysia, regardless of gender, as an attempt to reduce falls and the serious consequences of fall related injuries among older Malaysians.

The abbreviated suite of clinical assessment of balance incorporating static and dynamic component items for physical performance associated with falls risk provides clinicians with a brief set of tests to determine the presence and magnitude of impairment that can inform in particular exercise related interventions. Sit to stand, timed up and go test (dual task), functional reach test and step test are the recommended clinical measures of balance and mobility among this studied population. Furthermore, the key finding of turning impairment identified in this study, highlighted the importance of this measure to be applied in balance and mobility falls risk assessments. In addition, the FROP-Com provides a relatively brief but overall indication of falls risk across the range of most common risk factors, and was useful in the studied population.

The identification of turning impairment in this study as a contributor to falls risk is an important finding for clinicians, as it is generally not part of a physical performance assessment by physiotherapists of older people at risk of falling. However, the findings from the risk factor study, and the effectiveness of the targeted exercise intervention in addressing this risk factor, highlight the need for it to be considered in assessment batteries of physical performance and falls risk. However, the comprehensive force platform assessment of turning performance used in this study is not feasible for wide-spread clinical use, so there is a need to further evaluate other simple clinical methods of assessing turning ability for this screening purpose, such as a 10 item scale clinical tool to measure 180 degree turning performance (Dite & Temple, 2002a). This test was found to be reliable and valid as a clinical measure of turning while walking for older adults (Dite & Temple, 2002a). Furthermore, the observation of the type of turning strategy such as spin or step turn, time taken to perform turning and number of steps taken also could be used as parameters in identifying tuning performance, but warrant further investigation in the falls risk context.

These studies also demonstrated the effectiveness of an established home based, individualised falls prevention program (the Otago Exercise Program), combined with additional exercises to specifically train turning performance, as being effective in improving turning ability. Clinicians need to broaden their current exercise approaches to include turning related exercises, for those with identified turning impairment.

In summary, the main clinical implications from these studies are that clinicians should consider including assessment of turning ability in their assessment of older people with falls risk, and utilise exercises challenging stability during turning in a rehabilitation plan for those identified with turning impairment.

6.4 Strengths and limitations of these studies

A strength of the studies presented in this thesis included the comprehensive nature of the assessments conducted, utilising both clinical and laboratory measures, which was important given the paucity of risk factor data available to date on falls risk among Malaysians aged over 50 years. A further strength was the use of randomised controlled trial methodology consistent with the CONSORT statement, including use of concealment, single blind (assessor), eligibility criteria for participants included in the study, and diagram flow of participants through the trial. Concealment of group allocation was also utilised. The sample size was determined through a *priori* calculations. In addition, to reduce bias and improve power for the analysis, the consideration on missing data of the sample during follow up has been made through using the last value carried forward (LOCF) method (Molnar et al., 2008).

Though the studies in the present thesis have achieved the aims, there are a number of limitations that have been identified and discussed in previous chapters. However, the relevant main limitations are also stated below:

i. Data obtained in the cross-sectional study was based to retrospective recall of falls in the previous 12 months, which may result in under reporting of falls. Thus, in future, prospective studies are warranted to draw a robust finding for the incidence and predictors for falls among Malaysian older adults in the community setting, and to verify the findings from this study.

ii. Generalisability of the findings may be limited as participants were recruited on a voluntary basis, so there is a potential bias as it may not accurately represent the overall population of community dwelling Malaysians aged over 50 years.

iii. Selection of participants for the exercise program in the RCT required identification of impaired turning performance on an expensive force platform, which is not available in most clinical settings. More simple clinical measures to evaluate turning performance, without use of expensive analysis systems, are needed.

iv. Data used to define cuts offs in the turning task were obtained from laboratory measures of balance using data provided in the Neurocom™ Balance Master database (normative age and gender matched), which were based on an American sample. It is possible that cut offs may be slightly different in an Asian sample such as was used in these studies. However, data is compared to age and height referenced norms within the system. In addition, there may have been value in including executive function assessment in this sample.

v. As falls often result from interaction of intrinsic and extrinsic factors, evaluation of environmental risk may offer additional perspectives for a holistic view and understanding into fall risk factors in the studied sample. Future falls prevention studies of older community dwelling Malaysians should include a focus on environmental contributors to falls risk.

6.5 Future research direction

The findings presented in this thesis provide some important baseline information for falls prevention in the Malaysian context. Nonetheless, falls prevention research and practice in Malaysia is at a very early stage of development. There is a need for consideration of innovative approaches to fall prevention, that take into account local factors to support applicability, acceptability and availability, and for these to be evaluated in the context of rigorous randomised trials, with specific tailoring to maximise local uptake and sustained participation. There is also the need for an economic evaluation of the effective exercise approach utilised in the RCT in this thesis, to ensure it is cost effective in the Malaysian context. Similarly, cost effectiveness should be considered in other types of interventions being evaluated in Malaysia and other Asian countries, as these outcomes will vary substantially because of differences in costs and type of services available, compared to developed countries. A qualitative approach to investigate acceptability and feasibility study of the exercise intervention more widely among older Malaysians could be an important focus for future interventions.

6.6 Conclusion

Assessment of fall risk assessment is important to identify with consideration to local specific risk factors and to guide appropriate intervention. Despite a considerable number of studies on fall prevention that have been carried out, falls remain a significant problem associated with disability among community dwelling older people in both developed and developing countries. The findings of the present studies reveal new insights into the circumstances, consequences and correlates of risk factors for falls in the Malaysian context, and highlight that falls are a common problem among active community dwelling Malaysians over the age of 50 years. Findings also highlighted that one of the main factors discriminating fallers from non-fallers that has rarely been investigated in the past is unsteadiness during turning activities, and this risk factor warrants further investigation in terms of contributory factors and potential interventions. Study results also demonstrated that implementation of an individualised home based exercise program to improve specific turning balance impairment can be effective in improving turning performance. Finally, the study findings highlight the need for a strong focus on fall prevention in the primary healthcare system, including developing and implementing culturally appropriate and effective fall prevention programs in Malaysia.

LIST OF REFERENCES

Abbott, C.C. (2009). *Community multidimensional fall risk screening.* 3455519 (Ph.D.). University of Missouri - Columbia, Ann Arbor. Retrieved from http://search.proquest.com/docview/868724925?accountid=10382

ACSHQC. (2009). *Guidebook for Preventing Falls and Harms from falls in Older People*. Retrieved from http://www.safetyandquality.gov.au/wp-content/uploads/2009/01/30455-COMM-Guidebook1.pdf

Agrawal, Y., Carey, J.P., Della Santina, C.C., Schubert, M.C., & Minor, L.B. (2009). Disorders of balance and vestibular function in US adults: data from the National Health and Nutrition Examination Survey, 2001-2004. *Archives of Internal Medicine, 169*(10), 938-944.

Agrawal, Y., Carey, J.P., Della Santina, C.C., Schubert, M.C., & Minor, L.B. (2010). Diabetes, vestibular dysfunction, and falls: analyses from the National Health and Nutrition Examination Survey. *Otology & Neurotology, 31*(9), 1445-1450.

Akram, S.B., Frank, J.S., & Fraser, J. (2010). Effect of walking velocity on segment coordination during pre-planned turns in healthy older adults. *Gait & Posture, 32*(2), 211.

Alamgir, H., Wong, N.J., Hu, Y., Yu, M., Marshall, A., & Yu, S. (2015). Epidemiology of falls in older adults in Texas. *Southern Medical Journal, 108*(2), 119-124.

Altman, D.G., & Bland, J.M. (1996). Detecting skewness from summary information. *British Medical Journal, 313*(7066), 1200.

Ambrose, A.F., Paul, G., & Hausdorff, J.M. (2013). Risk factors for falls among older adults: A review of the literature. *Maturitas, 75*(1), 51-61.

Aoyagi, K., Ross, P.D., Davis, J.W., Wasnich, R.D., Hayashi, T., & Takemoto, T. (1998). Falls among community-dwelling elderly in Japan. *Journal of Bone and Mineral Research, 13*(9), 1468-1474.

Apikomonkon, H. (2003). *Fear of falling and fall circumstances in Thailand / Hataichanok Apikomonkon.* Thesis (M. Sc.)--Curtin University of Technology.

Ashari, A., Hamid, T.A., Hussain, M.R., & Hill, K.D. (2016). Effectiveness of Individualized Home-Based Exercise on Turning and Balance Performance Among Adults Older than 50 yrs: A Randomized Controlled Trial. *American Journal of Physical Medicine & Rehabilitation 95*(5), 355-365.

Asmidawati, A., Hamid, T.A., Hussain, M.R., & Hill, K.D. (2014). Home based exercise to improve turning and mobility performance among community dwelling older adults: protocol for a randomized controlled trial. *BMC Geriatrics, 14*(1), 100-109.

Assantachai, P., Chatthanawaree, W., Thamlikitkul, V., Praditsuwan, R., & Pisalsarakij, D. (2002). Strategy to prevent falls in the Thai elderly: a controlled study integrated health research program for the Thai elderly. *Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 85*(2), 215-222.

Assantachai, P., Praditsuwan, R., Chatthanawaree, W., Pisalsarakij, D., & Thamlikitkul, V. (2003). Risk factors for falls in the Thai elderly in an urban community. *Journal of the Medical Association of Thailand, 86*(2), 124-130.

Attebo, K., Mitchell, P., Cumming, R., Smith, W., Jolly, N., & Sparkes, R. (1998). Prevalence and causes of amblyopia in an adult population. *Ophthalmology, 105*(1), 154-159.

Axer, H., Axer, M., Sauer, H., Witte, O.W., & Hagemann, G. (2010). Falls and gait disorders in geriatric neurology. *Clinical Neurology and Neurosurgery, 112*(4), 265-274.

Baird, J.L., & Van Emmerik, R.E. (2009). Young and older adults use different strategies to perform a standing turning task. *Clinical Biomechanics 24*(10), 826-832.

Baloh, R.W., Enrietto, J., Jacobson, K.M., & Lin, A. (2001). Age-related changes in vestibular function a longitudinal study. *Annals of the New York Academy of Sciences, 942*, 210-219.

Barak, Y., Wagenaar, R.C., & Holt, K.G. (2006). Gait characteristics of elderly people with a history of falls: A dynamic approach. *Physical Therapy, 86*(11), 1501-1510.

Bastone, A.d.C., Moreira B. de, S., Vieira, R.A., Kirkwood, R.N., Dias, J.M., & Dias, R.C. (2014). Validation of the human activity profile questionnaire as a measure of physical activity levels in older community-dwelling women. *Journal of Aging and Physical Activity, 22*(3), 348-356.

Beauchet, O., Fantino, B., Allali, G., Muir, S.W., Montero-Odasso, M., & Annweiler, C. (2011). Timed Up and Go test and risk of falls in older adults: A systematic review. *The Journal of Nutrition, Health & Aging 15*(10), 933-938.

Bekibele, C.O., & Gureje, O. (2010). Fall incidence in a population of elderly persons in Nigeria. *Gerontology, 56*(3), 278-283.

Bennell, K.L., Hinman, R.S., Crossley, K.M., Metcalf, B.R., Buchbinder, R., Green, S., & McColl, G. (2004). Is the Human Activity Profile a useful measure in people with knee osteoarthritis? *Journal of Rehabilitation Research and Development, 41*(4), 621-630.

Berg, K. (1989). Balance and its measure in the elderly: A review. *Physiotherapy Canada, 41*(5), 240-246.

Berg, K., Wood-Dauphinee, S., & Williams, J.I. (1995). The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. *Scand J Rehabil Med, 27*(1), 27-36.

Berg, W.P., Alessio, H.M., Mills, E.M., & Tong, C. (1997). Circumstances and consequences of falls in independent community-dwelling older adults. *Age and Ageing, 26*(4), 261-268.

Bernhardt, J., Ellis, P., Denisenko, S., & Hill, K. (1998). Changes in balance and locomotion measures during rehabilitation following stroke. *Physiotherapy Research International, 3*(2), 109-122.

Bernhardt, J., & Hill, K.D. (2005). Chapter 2 - We only treat what it occurs to us to assess: the importance of knowledge-based assessment A2 - by, Edited. In K. Refshauge, L. Ada & E. Ellis (Eds.), *Science-Based Rehabilitation* (pp. 15-48). Edinburgh: Butterworth-Heinemann. http://dx.doi.org/:http://dx.doi.org/10.1016/B978-0-7506-5564-4.50005-X

Bertera, E.M., & Bertera, R.L. (2008). Fear of falling and activity avoidance in a national sample of older adults in the United States. *Health & Social Work, 33*(1), 54-62.

Bhatt, T., Espy, D., Yang, F., & Pai, Y.C. (2011). Dynamic gait stability, clinical correlates, and prognosis of falls among community-dwelling older adults. *Archives of Physical Medicine and Rehabilitation, 92*(5), 799-805.

Bilek, L.D., Venema, D.M., Camp, K.L., Lyden, E.R., & Meza, J.L. (2005). Evaluation of the human activity profile for use with persons with arthritis. *Arthritis and Rheumatism, 53*(5), 756-763.

Blake, A.J., Morgan, K., Bendall, M.J., Dallosso, H., Ebrahim, S.B., Arie, T.H., . . . Bassey, E.J. (1988). Falls by elderly people at home: prevalence and associated factors. *Age and Ageing, 17*(6), 365-372.

Blazer, D.G. (2003). Depression in late life: Review and commentary. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 58*(3), 249-265.

Bloom, D., David, C., & Jaypee, S. (2003). The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change.

Bock, O., & Beurskens, R. (2010). Changes of locomotion in old age depend on task setting. *Gait & Posture, 32*(4), 645-649.

Bohannon, R.W. (2006). Reference values for the timed up and go test: A descriptive meta-analysis. *Journal of Geriatric Physical Therapy, 29*(2), 64.

Bohannon, R.W. (2011). Test-retest reliability of the five-repetition sit-to-stand test: A systematic review of the literature involving adults. *Journal of Strength and Conditioning Research, 25*(11), 3205-3207.

Bohannon, R.W., Bubela, D.J., Magasi, S.R., Wang, Y.C., & Gershon, R.C. (2010). Sit-to-stand test: Performance and determinants across the age-span. *Isokinetics and Exercise Science, 18*(4), 235-240.

Bohannon, R.W., Shove, M.E., Barreca, S.R., Masters, L.M., & Sigouin, C.S. (2007). Five-repetition sit-to-stand test performance by community-dwelling adults: A preliminary investigation of times, determinants, and relationship with self-reported physical performance. *Isokinetics and Exercise Science, 15*(2), 77-81.

Bongers, K.T., Schoon, Y., Graauwmans, M.J., Schers, H.J., Melis, R.J., & Olde Rikkert, M.G. (2015). The predictive value of gait speed and maximum step length for falling in community-dwelling older persons. *Age and Ageing, 44*(2), 294-299.

Boyd, R., & Stevens, J.A. (2009). Falls and fear of falling: burden, beliefs and behaviours. *Age and Ageing, 38*(4), 423-428.

Braun, B.J. (1998). Knowledge and perception of fall-related risk factors and fall-reduction techniques among community-dwelling elderly individuals. *Physical Therapy 78*(12), 1262-1276.

Buatois, S., Miljkovic, D., Manckoundia, P., Gueguen, R., Miget, P., Vancon, G., . . . Benetos, A. (2008). Five times sit to stand test is a predictor of recurrent falls in healthy community-living subjects aged 65 and older. *Journal of the American Geriatrics Society, 56*(8), 1575-1577.

Buchner, D.M., Hornbrook, M.C., Kutner, N.G., Tinetti, M.E., Ory, M.G., Mulrow, C.D., . . . et al. (1993). Development of the common data base for the FICSIT trials. *Journal of the American Geriatrics Society 41*(3), 297-308.

Campbell, A., Robertson, M., Gardner, M., Norton, R., Tilyard, M., & Buchner, D. (1997a). Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *British Medical Journal (Clinical Research Ed.), 315*(7115), 1065-1069.

Campbell, A.J., Borrie, M.J., & Spears, G.F. (1989). Risk factors for falls in a community-based prospective study of people 70 years and older. *Journal of Gerontology, 44*(4), M112-117.

Campbell, A.J., Robertson, M.C., Gardner, M.M., Norton, R.N., Tilyard, M.W., & Buchner, D.M. (1997b). Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ, 315*(7115), 1065-1069.

Campbell, A.J., Robertson, M.C., La Grow, S.J., Kerse, N.M., Sanderson, G.F., Jacobs, R.J., . . . Hale, L.A. (2005). Randomised controlled trial of prevention of falls in people aged > or =75 with severe visual impairment: the VIP trial. *BMJ Case Reports, 331*(7520), 817.

Canadian Institute for Health Information. (2002). *RAI–Home Care (RAI–HC) manual* (2 ed.). Ottawa.

Carter, N.D., Khan, K.M., McKay, H.A., Petit, M.A., Waterman, C., Heinonen, A., . . . Flicker, L. (2002). Community-based exercise program reduces risk factors for falls in 65- to 75-year-old women with osteoporosis: randomized controlled trial. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne, 167*(9), 997-1004.

Carter, S.E., Campbell, E.M., Sanson-Fisher, R.W., & Gillespie, W.J. (2000). Accidents in older people living at home: a community-based study assessing prevalence, type, location and injuries. *Australian and New Zealand Journal of Public Health, 24*(6), 633-636.

Carty, C.P., Cronin, N.J., Nicholson, D., Lichtwark, G.A., Mills, P.M., Kerr, G., . . . Barrett, R.S. (2015). Reactive stepping behaviour in response to forward loss of balance predicts future falls in community-dwelling older adults. *Age and ageing 44*(1), 109-115.

Centers for Disease Control, & Prevention. (2008). Self-reported falls and fall-related injuries among persons aged > or =65 years-United States, 2006. Mar 7. *MMWR Morb Mortal Wkly Rep* Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18322444

Centers for Disease Control and Prevention. (2012). Older Adult Falls. *Preventing Falls Among Older Adults* Retrieved from http://www.cdc.gov/Features/OlderAmericans/index.html

Cesari, M., Landi, F., Torre, S., Onder, G., Lattanzio, F., & Bernabei, R. (2002). Prevalence and risk factors for falls in an older community-dwelling population. *Journal of Gerontology: Medical Sciences, 57*(11), M722-726.

Cevizci, S., Uluocak, S., Aslan, C., Gokulu, G., Bilir, O., & Bakar, C. (2015). Prevalence of falls and associated risk factors among aged population; comminty based cross sectional study from Turkey. *Central European Journal of Public Health, 23*(3), 233-239.

Chan, K.M., Pang, W.S., Ee, C.H., Ding, Y.Y., & Choo, P. (1997). Epidemiology of falls among the elderly community dwellers in Singapore. *Singapore Medical Journal, 38*(10), 427-431.

Chang, H.T., Chen, H.C., & Chou, P. (2016). Factors Associated with Fear of Falling among Community-Dwelling Older Adults in the Shih-Pai Study in Taiwan. *PLoS One, 11*(3), e0150612.

Chang, N.T., Yang, N.P., & Chou, P. (2010). Incidence, risk factors and consequences of falling injuries among the community-dwelling elderly in Shihpai, Taiwan. *Aging Clinical and Experimental Research, 22*(1), 70-77.

Chang, V.C., & Do, M.T. (2015). Risk Factors for Falls Among Seniors: Implications of Gender. *American Journal of Epidemiology, 181*(7), 521-531.

Chao, Y.Y., Scherer, Y.K., Montgomery, C.A., Wu, Y.W., & Lucke, K.T. (2015). Physical and psychosocial effects of Wii Fit Exergames use in assisted living residents: A pilot study. *Clinical Nursing Research, 24*(6), 589-603.

Chen, I.-H., Yang, Y.-R., Chan, R.-C., & Wang, R.-Y. (2014). Turning-based treadmill training improves turning performance and gait symmetry after stroke. *Neurorehabilitation and Neural Repair, 28*(1), 45-55.

Cho, B.L., Scarpace, D., & Alexander, N.B. (2004). Tests of stepping as indicators of mobility, balance, and fall risk in balance-impaired older adults. *Journal of the American Geriatrics Society, 52*(7), 1168-1173.

Choi, W.J., Wakeling, J.M., & Robinovitch, S.N. (2015). Kinematic analysis of video-captured falls experienced by older adults in long-term care. *Journal of Biomechanics 48*(6), 911-920.

Chu, L.W., Chi, I., & Chiu, A.Y. (2005). Incidence and predictors of falls in the Chinese elderly. *Annals of the Academy of Medicine, Singapore, 34*(1), 60-72.

Chu, L.W., Chiu, A.Y., & Chi, I. (2006). Impact of falls on the balance, gait, and activities of daily living functioning in community-dwelling Chinese older adults. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 61*(4), 399-404.

Chu, L.W., Pei, C.K.W., Chiu, A., Liu, K., Chu, M.M.L., Wong, S., & Wong, A. (1999). Risk factors for falls in hospitalized older medical patients. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 54*(1), M38-M43.

Clark, S., & Rose, D.J. (2001). Evaluation of dynamic balance among community-dwelling older adult fallers: A generalizability study of the limits of stability test. *Archives of Physical Medicine and Rehabilitation, 82*(4), 468-474.

Clements, R.M. (2008). Reducing psychotropic medications in elderly rehabilitation inpatients with a fall-related admission: how often is it happening? *Geriatrics & Gerontology International, 8*(3), 139-142.

Clemson, L., Fiatarone Singh, M.A., Bundy, A., Cumming, R.G., Manollaras, K., O'Loughlin, P., & Black, D. (2012). Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial. *BMJ, 345*, 1-15.

Close, J., Ellis, M., Hooper, R., Glucksman, E., Jackson, S., & Swift, C. (1999). Prevention of falls in the elderly trial (PROFET): A randomised controlled trial. *Lancet, 353*(9147), 93-97.

Close, J.C. (2001). Interdisciplinary practice in the prevention of falls. A review of working models of care. *Age and Ageing, 30 Suppl 4*, 8-12.

Close, J.C., & Lord, S.R. (2011). Fall assessment in older people. *BMJ, 343*, d5153.

Cromwell, R.L., Newton, R.A., & Forrest, G. (2002). Influence of vision on head stabilization strategies in older adults during walking. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 57*(7), M442-448.

Cumming, R., & Klineberg, R. (1994). Fall frequency and characteristics and the risk of hip fractures. *Journal of American Geriatric Society, 42*(7), 774 - 778.

Cumming, R.G. (1998). Epidemiology of medication-related falls and fractures in the elderly. *Drugs and Aging, 12*(1), 43-53.

Cummings, S.R., Nevitt, M.C., & Kidd, S. (1988). Forgetting falls. The limited accuracy of recall of falls in the elderly. *Journal of the American Geriatrics Society, 36*(7), 613-616.

Daly, R.M., Duckham, R.L., Tait, J.L., Rantalainen, T., Nowson, C.A., Taaffe, D.R., . . . Busija, L. (2015). Effectiveness of dual-task functional power training for preventing falls in older people: study protocol for a cluster randomised controlled trial. *Trials, 16*, 120.

Davidson, M., & de Morton, N. (2007). A systematic review of the Human Activity Profile. *Clinical Rehabilitation, 21*(2), 151-162.

Deandrea, S., Lucenteforte, E., Bravi, F., Foschi, R., La Vecchia, C., & Negri, E. (2010). Risk factors for falls in community-dwelling older people: A systematic review and meta-analysis. *Epidemiology, 21*(5), 658-668.

Delbaere, K., Bourgois, J., Van Den Noortgate, N., Vanderstraeten, G., Willems, T., & Cambier, D. (2006). A home-based multidimensional exercise program reduced physical impairment and fear of falling. *Acta Clinica Belgica, 61*(6), 340-350.

Delbaere, K., Close, J.C., Mikolaizak, A.S., Sachdev, P.S., Brodaty, H., & Lord, S.R. (2010). The Falls Efficacy Scale International (FES-I). A comprehensive longitudinal validation study. *Age and Ageing, 39*(2), 210-216.

Delbaere, K., Sherrington, C., & Lord, S.R. (2013). Chapter 70 - Falls Prevention Interventions. In R. Marcus, D. Feldman, D. W. Dempster, M. Luckey & J. A. Cauley (Eds.), *Osteoporosis (Fourth Edition)* (pp. 1649-1666). San Diego: Academic Press. http://dx.doi.org/:http://dx.doi.org/10.1016/B978-0-12-415853-5.00070-4

Deshpande, N., Metter, E.J., Lauretani, F., Bandinelli, S., Guralnik, J., & Ferrucci, L. (2008). Activity restriction induced by fear of falling and objective and subjective measures of physical function: A prospective cohort study. *Journal of the American Geriatrics Society, 56*(4), 615-620.

Dieterich, M., & Brandt, T. (2001). Vestibular system: Anatomy and functional magnetic resonance imaging. *Neuroimaging Clinics of North America, 11*(2), 263-273, ix.

Dite, W., & Temple, V. (2002a). Development of a clinical measure of turning for older adults. *American Journal of Physical, Medicine and Rehabilitation, 81*(11), 857 - 866.

Dite, W., & Temple, V.A. (2002b). A clinical test of stepping and change of direction to identify multiple falling older adults. *Archives of Physical Medicine and Rehabilitation, 83*(11), 1566-1571.

Dolinis, J., Harrison, J.E., & Andrews, G.R. (1997). Factors associated with falling in older Adelaide residents. *Australian and New Zealand Journal of Public Health 21*(5), 462-468.

Dormann, C.F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., . . . Leitão, P.J. (2013). Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography, 36*(1), 27-46.

DOSM. (2011). *Population distribution and basic demographic characteristics 2010. Population and Housing Census of Malaysia, 2010*. Putrajaya: Department of Statistics of Malaysia.

DOSM. (2013). *Vital Statististics, Malaysia, 2012*. Putrajaya: Department of Statistics of Malaysia.

DOSM. (2015). *Vital Statistics Malaysia, 2014*. Putrajaya: Department of Statistics of Malaysia.

Dsouza, S.A., Rajashekar, B., Dsouza, H., & Kumar, K. (2014). Falls in Indian older adults: a barrier to active ageing. *Asian Journal of Gerontology Geriatric, 9*(1), 1-8.

Duncan, P.W., Weiner, D.K., Chandler, J., & Studenski, S. (1990). Functional reach: a new clinical measure of balance. *Journal of Gerontology 45*(6), M192-M197.

Dunlop, D.D., Manheim, L.M., Sohn, M.W., Liu, X., & Chang, R.W. (2002). Incidence of functional limitation in older adults: the impact of gender, race, and chronic conditions. *Archives of Physical Medicine and Rehabilitation, 83*(7), 964-971.

Ekvall Hansson, E., & Magnusson, M. (2013). Vestibular asymmetry predicts falls among elderly patients with multi-sensory dizziness. *BMC Geriatrics, 13*, 77.

Elliott, S., Painter, J., & Hudson, S. (2009). Living alone and fall risk factors in community-dwelling middle age and older adults. *Journal of Community Health, 34*(4), 301-310.

Eun, J.C., Sun, A.K., Jung, A.R., Yong, W.Y., & Min, H.S. (2015). Erratum: Correction of Prevalence of Falls by Sex in Article 'Risk Factors for Falls in Older Korean Adults: The 2011 Community Health Survey". *Journal Korean Medical Sciences, 30*(1)

Faul, M., Stevens, J.A., Sasser, S.M., Alee, L., Deokar, A.J., Kuhls, D.A., & Burke, P.A. (2016). Older adult falls seen by emergency medical service providers: A prevention opportunity. *American Journal of Preventive Medicine* http://dx.doi.org/10.1016/j.amepre.2015.12.011

Faulkner, K.A., Cauley, J.A., Zmuda, J.M., Landsittel, D.P., Nevitt, M.C., Newman, A.B., . . . Redfern, M.S. (2005). Ethnic differences in the frequency and circumstances of falling in older community-dwelling women. *Journal of the American Geriatrics Society, 53*(10), 1774-1779.

Fink, H.A., Kuskowski, M.A., & Marshall, L.M. (2014). Association of stressful life events with incident falls and fractures in older men: the Osteoporotic Fractures in Men (MrOS) Study. *Age and Ageing, 43*(1), 103-108.

Finlayson, M.L., & Peterson, E.W. (2010). Falls, aging, and disability. *Physical Medicine and Rehabilitation Clinics of North America, 21*(2), 357-373.

Fiske, A., Wetherell, J.L., & Gatz, M. (2009). Depression in Older Adults. *Annual Review of Clinical Psychology, 5*, 363-389.

Fix, A.J., & Daughton, D. (1988). *Human activity profile: Professional Manual*: Psychological Assessment Resources.

Fletcher, P.C., Guthrie, D.M., Berg, K., & Hirdes, J.P. (2010). Risk factors for restriction in activity associated with fear of falling among seniors within the community. *Journal of Patient Safety, 6*(3), 187-191.

Gazzola, J.M., Perracini, M.R., Gananca, M.M., & Gananca, F.F. (2006). Functional balance associated factors in the elderly with chronic vestibular disorder. *Brazilian Journal of Otorhinolaryngology, 72*(5), 683-690.

Gibson, M.J., Andres, R.O., Isaacs, B., Radebaugh, T., & Worm-Petersen, J. (1987). The prevention of falls in later life. A report of the Kellogg International Work Group on the Prevention of Falls by the Elderly. *Danish Medical Bulletin, 34 Suppl 4*, 1-24.

Gillespie, L.D., Robertson, M.C., Gillespie, W.J., Sherrington, C., Gates, S., Clemson, L.M., & Lamb, S.E. (2012). Interventions for preventing falls in older people living in the community. *The Cochrane Database of Systematic Reviews, 9*, CD007146.

Gittings, N.S., & Fozard, J.L. (1986). Age related changes in visual acuity. *Experimental Gerontology, 21*(4-5), 423-433.

Glaister, B.C., Bernatz, G.C., Klute, G.K., & Orendurff, M.S. (2007). Video task analysis of turning during activities of daily living. *Gait & Posture, 25*(2), 289-294.

Graafmans, W.C., Ooms, M.E., Hofstee, H.M., Bezemer, P.D., Bouter, L.M., & Lips, P. (1996). Falls in the elderly: a prospective study of risk factors and risk profiles. *American Journal of Epidemiology, 143*(11), 1129-1136.

Greenberg, S.A. (2012). The geriatric depression scale (GDS). *Best Practices in Nursing Care to Older Adults, 4*, 1-2.

Grisso, J.A., Kelsey, J.L., Strom, B.L., Chiu, G.Y., Maislin, G., O'Brien, L.A., . . . Kaplan, F. (1991). Risk factors for falls as a cause of hip fracture in women. The Northeast Hip Fracture Study Group. *The New England Journal of Medicine 324*(19), 1326-1331.

Grundstrom, A.C., Guse, C.E., & Layde, P.M. (2012). Risk factors for falls and fall-related injuries in adults 85 years of age and older. *Archives of Gerontology and Geriatrics, 54*(3), 421-428.

Gschwind, Y.J., Eichberg, S., Ejupi, A., de Rosario, H., Kroll, M., Marston, H.R., . . . Delbaere, K. (2015). ICT-based system to predict and prevent falls (iStoppFalls): results from an international multicenter randomized controlled trial. *European Review of Aging and Physical Activity 12*, 10.

Hamid, T.A. (2012). Population Ageing: Past, Present and Future Trends. In T. A. Hamid, S. Husna & Z. A. Siti Farra (Eds.), *Profile of Older Malaysians: Current and Future Challenges*. Serdang: University Putra Malaysia.

Hamid, T.A. (2015). *Population ageing in Malaysia: A mosaic of issues, challenges and prospects* (1 ed.). Serdang, Selangor: Universiti Putra Malaysia.

Hamid, T.A., Momtaz, Y.A., & Ibrahim, R. (2012). Predictors and prevalence of successful aging among older Malaysians. *Gerontology, 58*(4), 366-370.

Hammond, T., & Wilson, A. (2013). Polypharmacy and falls in the elderly: a literature review. *Nursing and Midwifery Studies, 2*(2), 171-175.

Han, B.H., Ferris, R., & Blaum, C. (2014). Exploring ethnic and racial differences in falls among older adults. *Journal of Community Health, 39*(6), 1241-1247.

Hanlon, J.T., Landerman, L.R., Fillenbaum, G.G., & Studenski, S. (2002). Falls in African American and white community-dwelling elderly residents. *Journals of Gerontology: Series A: Biological Sciences and Medical Sciences, 57A*(7), M473-M478.

Hannan, M.T., Gagnon, M.M., Aneja, J., Jones, R.N., Cupples, L.A., Lipsitz, L.A., . . . Kiel, D.P. (2010). Optimizing the tracking of falls in studies of older participants: comparison of quarterly telephone recall with monthly falls calendars in the MOBILIZE Boston Study. *American Journal of Epidemiology, 171*(9), 1031-1036.

Haran, M.J., Cameron, I.D., Ivers, R.Q., Simpson, J.M., Lee, B.B., Tanzer, M., . . . Lord, S.R. (2010). Effect on falls of providing single lens distance vision glasses to multifocal glasses wearers: VISIBLE randomised controlled trial. *BMJ Case Reports, 340*, c2265.

Hartholt, K.A., van Beeck, E.F., Polinder, S., van der Velde, N., van Lieshout, E.M., Panneman, M.J., . . . Patka, P. (2011). Societal consequences of falls in the older population: injuries, healthcare costs, and long-term reduced quality of life. *Journal of Trauma-Injury, Infection, and Critical Care, 71*(3), 748-753.

Hartikainen, S., Lonnroos, E., & Louhivuori, K. (2007). Medication as a risk factor for falls: critical systematic review. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 62*(10), 1172-1181.

Hase, K., & Stein, R. (1999). Turning strategies during human walking. *Journal of Neurophysiology, 81*(6), 2914-2922.

Hasselmann, V., Oesch, P., Fernandez-Luque, L., & Bachmann, S. (2015). Are exergames promoting mobility an attractive alternative to conventional self-regulated exercises for elderly people in a rehabilitation setting? Study protocol of a randomized controlled trial. *BMC Geriatrics 15*, 108.

Hauer, K., Lamb, S.E., Jorstad, E.C., Todd, C., Becker, C., & Group, P. (2006). Systematic review of definitions and methods of measuring falls in randomised controlled fall prevention trials. *Age and Ageing, 35*(1), 5-10.

Hausdorff, J.M., Rios, D.A., & Edelberg, H.K. (2001). Gait variability and fall risk in community-living older adults: a 1-year prospective study. *Archives of Physical Medicine and Rehabilitation, 82*(8), 1050-1056.

Heinrich, S., Rapp, K., Rissmann, U., Becker, C., & Konig, H.H. (2010). Cost of falls in old age: A systematic review. *Osteoporosis International, 21*(6), 891-902.

Herdman, S.J., Blatt, P., Schubert, M.C., & Tusa, R.J. (2000). Falls in patients with vestibular deficits. *The American Journal of Otology, 21*(6), 847-851.

Hester, A.L., & Davis, D.M. (2013). Validation of the Hester Davis Scale for fall risk assessment in a neurosciences population. *The Journal of Neuroscience, 45*(5), 298-305.

Hill, K.D., Bernhardt, J., McGann, A.M., Maltese, D., & Berkovits, D. (1996). A new test of dynamic standing balance for stroke patients: reliability, validity and comparison with healthy elderly. *Physiotherapy Canada, 48*(4), 257 - 262.

Hill, K.D., Fearn, M., Williams, S., Mudge, L., Walsh, C., McCarthy, P., . . . Street, A. (2010). Effectiveness of a balance training home exercise programme for adults with haemophilia: a pilot study. *Haemophilia, 16*(1), 162-169.

Hill, K.D., LoGiudice, D., Lautenschlager, N., Said, C., Dodd, K., & Suttanon, P. (2009). Effectiveness of balance training exercise in people with mild to moderate severity Alzheimer's disease: protocol for a randomised trial. *BMC Geriatrics, 9*(1), 29.

Hill, K.D., & Schwarz, J. (2004). Assessment and management of falls in older people. *Internal Medicine Journal, 34*(9-10), 557-564.

Hill, K.D., Schwarz, J., Flicker, L., & Carroll, S. (1999). Falls among healthy, community• dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy. *Australian and New Zealand Journal of Public Health, 23*(1), 41-48.

Holt, K.R., Noone, P.L., Short, K., Elley, C.R., & Haavik, H. (2011). Fall risk profile and quality-of-life status of older chiropractic patients. *Journal of Manipulative and Physiological Therapeutics, 34*(2), 78-87.

Hong, G.R., Cho, S.H., & Tak, Y. (2010). Falls among Koreans 45 years of age and older: incidence and risk factors. *Journal of Advanced Nursing, 66*(9), 2014-2024.

Hong, S.J., Goh, E.Y., Chua, S.Y., & Ng, S.S. (2012). Reliability and validity of step test scores in subjects with chronic stroke. *Archives of Physical Medicine and Rehabilitation, 93*(6), 1065-1071.

Horak, F.B. (2006). Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? *Age and Ageing, 35 Suppl 2*, ii7-ii11.

Horak, F.B., Wrisley, D.M., & Frank, J. (2009). The balance evaluation systems test (BESTest) to differentiate balance deficits. *Physical Therapy, 89*(5), 484.

Howe, T.E., Rochester, L., Neil, F., Skelton, D.A., & Ballinger, C. (2011). Exercise for improving balance in older people. *The Cochrane Database of Systematic Reviews,* (11), CD004963. http://dx.doi.org/10.1002/14651858.CD004963.pub3

Howland, J., Peterson, E.W., Levin, W.C., Fried, L., Pordon, D., & Bak, S. (1993). Fear of falling among the community-dwelling elderly. *Journal of Aging and Health, 5*(2), 229-243.

Hu, G., & Baker, S.P. (2010). Recent increases in fatal and non-fatal injury among people aged 65 years and over in the USA. *Injury Prevention, 16*(1), 26-30.

Hu, G., & Baker, S.P. (2012). An explanation for the recent increase in the fall death rate among older Americans: a subgroup analysis. *Public Health Reports, 127*(3), 275-281.

Hu, J., Xia, Q., Jiang, Y., Zhou, P., & Li, Y. (2015). Risk factors of indoor fall injuries in community-dwelling older women: A prospective cohort study. *Archives of Gerontology and Geriatrics, 60*(2), 259-264.

Hua, F., Yoshida, S., Junling, G., & Hui, P. (2007). Falls Prevention in Older Age in Western Pacific Asia Region. *WHO background paper to the global report on falls among older persons* Retrieved from http://www.who.int/ageing/projects/WPRO.pdf?ua=1

Huang, H.C., Liu, C.Y., Huang, Y.T., & Kernohan, W.G. (2010). Community-based interventions to reduce falls among older adults in Taiwan - long time follow-up randomised controlled study. *Journal of Clinical Nursing, 19*(7-8), 959-968.

Huang, T.T., & Acton, G.J. (2004). Effectiveness of home visit falls prevention strategy for Taiwanese community-dwelling elders: randomized trial. *Public Health Nursing, 21*(3), 247-256.

Huang, T.T., & Liang, S.H. (2005). A randomized clinical trial of the effectiveness of a discharge planning intervention in hospitalized elders with hip fracture due to falling. *Journal Clinical Nursing, 14*(10), 1193-1201.

Huang, T.T., Yang, L.H., & Liu, C.Y. (2011). Reducing the fear of falling among community-dwelling elderly adults through cognitive-behavioural strategies and intense Tai Chi exercise: a randomized controlled trial. *J Adv Nurs, 67*(5), 961-971.

Hudson, J. (1996). *Biomechanics of balance: Paradigms and procedures.* Paper presented at the Proceedings of the XIII th International Symposium on Biomechanics in Sports, Thunder Bay, Ontario, Canada: Lakehead University

Ivers, R.Q., Cumming, R.G., Mitchell, P., & Attebo, K. (1998). Visual impairment and falls in older adults: the Blue Mountains Eye Study. *Journal of the American Geriatrics Society, 46*(1), 58-64.

Iwamoto, J., Suzuki, H., Tanaka, K., Kumakubo, T., Hirabayashi, H., Miyazaki, Y., . . . Matsumoto, H. (2009). Preventative effect of exercise against falls in the elderly: a randomized controlled trial. *Osteoporos Int, 20*(7), 1233-1240.

Jagnoor, Keay, L., & Ivers, R. (2013). A slip and a trip? Falls in older people in Asia. *Injury, 44*(6), 701-702.

Jagnoor, J., Keay, L., Jaswal, N., Kaur, M., & Ivers, R. (2014). A qualitative study on the perceptions of preventing falls as a health priority among older people in Northern India. *Injury Prevention : Journal of the International Society for Child and Adolescent Injury Prevention, 20*(1), 29-34.

Jerome, G.J., Ko, S.U., Kauffman, D., Studenski, S.A., Ferrucci, L., & Simonsick, E.M. (2015). Gait characteristics associated with walking speed decline in older adults: results from the Baltimore Longitudinal Study of Aging. *Archives of Gerontology and Geriatrics, 60*(2), 239-243.

Jiang, J., Long, J., Ling, W., Huang, G., Guo, X., & Su, L. (2015). Incidence of fall-related injury among old people in mainland China. *Archives of Gerontology and Geriatrics, 61*(2), 131-139.

Jitapunkul, S. (1998). A randomised controlled trial of regular surveillance in Thai elderly using a simple questionnaire administered by non-professional personnel. *Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 81*(5), 352-356.

Jitapunkul, S., Songkhla, M.N., Chayovan, N., Chirawatkul, A., Choprapawon, C., Kachondham, Y., & Buasai, S. (1998a). Factors associated with state hospital utilisation among Thai elderly who had illnesses which needed hospitalisation. *Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 81*(9), 658-664.

Jitapunkul, S., Songkhla, M.N., Chayovan, N., Chirawatkul, A., Choprapawon, C., Kachondham, Y., & Buasai, S. (1998b). Falls and their associated factors: a national survey of the Thai elderly. *Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 81*(4), 233-242.

Johansen, K.L., Painter, P., Kent-Braun, J.A., Ng, A.V., Carey, S., Da Silva, M., & Chertow, G.M. (2001). Validation of questionnaires to estimate physical activity and functioning in end-stage renal disease. *Kidney International, 59*(3), 1121-1127.

Justine, M., Haidzir, M., Sulaiman, A., Razi, S., & Hani Asilah, A. (2014). Sharp Turning and Corner Turning: Comparison of Energy Expenditure, Gait Parameters, and Level of Fatigue among Community-Dwelling Elderly. *BioMed Research International*, http://dx.doi.org/http://dx.doi.org/10.1155/2014/640321

Kalula, S.Z., Scott, V., Dowd, A., & Brodrick, K. (2011). Falls and fall prevention programmes in developing countries: Environmental scan for the adaptation of the Canadian Falls prevention curriculum for developing countries. *Journal of Safety Research, 42*(6), 461-472.

Kamide, N., Shiba, Y., & Shibata, H. (2009). Effects on balance, falls, and bone mineral density of a home-based exercise program without home visits in community-dwelling elderly women: a randomized controlled trial. *Journal of Physiological Anthropology, 28*(3), 115-122.

Kamide, N., Takahashi, K., & Shiba, Y. (2011). Reference values for the Timed Up and Go test in healthy Japanese elderly people: determination using the methodology of meta-analysis. *Geriatrics & Gerontology International, 11*(4), 445-451.

Kellogg International Work Group. (1987). *The prevention of falls in later life. A report of the Kellogg International Work Group on the Prevention of Falls by the Elderly* (0907-8916 (Print)
0907-8916 (Linking)). Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3595217

Kempen, G.I., Yardley, L., Van Haastregt, J.C., Zijlstra, G.R., Beyer, N., Hauer, K., & Todd, C. (2008). The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling. *Age and Ageing, 37*(1), 45-50.

Khalil, N., Cauley, J.A., Wilson, J.W., Talbott, E.O., Morrow, L., Hochberg, M.C., . . . Cummings, S.R. (2008). Relationship of blood lead levels to incident nonspine fractures and falls in older women: the study of osteoporotic fractures. *Journal of Bone Mineral Research, 23*(9), 1417-1425.

Kim, H., Yoshida, H., & Suzuki, T. (2014). Falls and fractures in participants and excluded non-participants of a fall prevention exercise program for elderly women with a history of falls: 1-year follow-up study. *Geriatrics & Gerontology International, 14*(2), 285-292.

Kim, S., & So, W.Y. (2013). Prevalence and correlates of fear of falling in Korean community-dwelling elderly subjects. *Experimental Gerontology, 48*(11), 1323-1328.

Kinsella, K.G., & Velkoff, V.A. (2001). *U.S. Census Bureau*. Washington: Government Printing Office.

Kojima, S., Furuna, T., Ikeda, N., Nakamura, M., & Sawada, Y. (2008). Falls among community-dwelling elderly people of Hokkaido, Japan. *Geriatrics & Gerontology International, 8*(4), 272-277.

Kojima, T., Akishita, M., Nakamura, T., Nomura, K., Ogawa, S., Iijima, K., . . . Ouchi, Y. (2012). Polypharmacy as a risk for fall occurrence in geriatric outpatients. *Geriatrics & Gerontology International, 12*(3), 425-430.

Kong, K.S.W., Lee, F.K., Mackenzie, A.E., & Lee, D.T.F. (2002). Psychosocial consequences of falling: the perspective of older Hong Kong Chinese who had experienced recent falls. *Journal of Advanced Nursing, 37*(3), 234-242.

Krishnaswamy, B., & Usha, G. (2006). *Falls in older people: National/ Regional review India*. Government General Hospital Chennai City, India: Retrieved from http://www.who.int/ageing/projects/SEARO.pdf.

Kua, E.H., & Ko, S.M. (1992). A questionnaire to screen for cognitive impairment among elderly people in developing countries. *Acta Psychiatrica Scandinavica, 85*(2), 119-122.

Kwan, M.M., Close, J.C.T., Wong, A.K.W., & Lord, S.R. (2011a). Falls incidence, risk factors, and consequences in Chinese older people: a systematic review. *Journal of the American Geriatrics Society, 59*(3), 536-543.

Kwan, M.M., Lin, S.I., Chen, C.H., Close, J.C., & Lord, S.R. (2011b). Sensorimotor function, balance abilities and pain influence Timed Up and Go performance in older community-living people. *Aging Clinical and Experimental Research, 23*(3), 196-201.

Kwan, M.M., Tsang, W.W., Lin, S.I., Greenaway, M., Close, J.C., & Lord, S.R. (2013a). Increased concern is protective for falls in Chinese older people: the chopstix fall risk study. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 68*(8), 946-953.

Kwan, M.M.S., Tsang, W.W.N., Close, J.C.T., & Lord, S.R. (2013b). Development and validation of a Chinese version of the Falls Efficacy Scale International. *Archives of Gerontology and Geriatrics, 56*(1), 169-174.

Lach, H.W. (2002). Fear of falling: an emerging public health problem. *Generations, 26*(4), 33-37.

Lachman, M.E., Howland, J., Tennstedt, S., Jette, A., Assmann, S., & Peterson, E.W. (1998). Fear of falling and activity restriction: the survey of activities and fear of falling in the elderly (SAFE). *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 53*(1), 43-50.

Lamb, S.E., Becker, C., Gillespie, L.D., Smith, J.L., Finnegan, S., Potter, R., . . . Taxonomy, I. (2011). Reporting of complex interventions in clinical trials:

development of a taxonomy to classify and describe fall-prevention interventions. *Trials, 12*, 125.

Lamb, S.E., Jørstad-Stein, E.C., Hauer, K., & Becker, C. (2005). Development of a common outcome data set for fall injury prevention trials: the prevention of Falls Network Europe consensus. *Journal of the American Geriatrics Society, 53*(9), 1618-1622.

Langley, F., & Mackintosh, S.F. (2007). Functional balance assessment of older community dwelling adults: a systematic review of the literature. *The Internet Journal of Allied Health Sciences and Practice, 5*(4), 1-11.

Lee, A., Lee, K.W., & Khang, P. (2013a). Preventing falls in the geriatric population. *The Permanente Journal, 17*(4), 37-39.

Lee, J., Geller, A.I., & Strasser, D.C. (2013b). Analytical review: focus on fall screening assessments. *The Journal of Injury, Function, and Rehabilitation, 5*(7), 609-621.

Leung, A., Chi, I., Lou, V.W., & Chan, K.S. (2010). Psychosocial risk factors associated with falls among Chinese community dwelling older adults in Hong Kong. *Health & Social Care in the Community, 18*(3), 272-281.

Li, F., Fisher, K.J., Harmer, P., McAuley, E., & Wilson, N.L. (2003). Fear of falling in elderly persons: association with falls, functional ability, and quality of life. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58*(5), P283-P290.

Lin, M.R., Wolf, S.L., Hwang, H.F., Gong, S.Y., & Chen, C.Y. (2007). A randomized, controlled trial of fall prevention programs and quality of life in older fallers. *Journal of the American Geriatrics Society, 55*(4), 499-506.

Lindsey, P.L. (2009). Psychotropic medication use among older adults: what all nurses need to know. *Journal of Gerontological Nursing, 35*(9), 28-38.

Liston, R.A., & Brouwer, B.J. (1996). Reliability and validity of measures obtained from stroke patients using the Balance Master. *Archives of Physical Medicine and Rehabilitation, 77*(5), 425-430.

Lord, S., Howe, T., Greenland, J., Simpson, L., & Rochester, L. (2011). Gait variability in older adults: a structured review of testing protocol and clinimetric properties. *Gait Posture, 34*(4), 443-450.

Lord, S.R., Menz, H.B., & Tiedemann, A. (2003). A physiological profile approach to falls risk assessment and prevention. *Physical Therapy Forum, 83*(3), 237-252.

Lord, S.R., Sambrook, P.N., Gilbert, C., Kelly, P.J., Nguyen, T., Webster, I.W., & Eisman, J.A. (1994). Postural stability, falls and fractures in the elderly: results from the Dubbo Osteoporosis Epidemiology Study. *The Medical Journal of Australia, 160*(11), 684-685, 688-691.

Lord, S.R., Sherrington, C., Menz, H.B., & Close, J.C. (2007). *Falls in older people: risk factors and strategies for prevention* (2nd ed.). New York, USA: Cambridge University Press.

Lord, S.R., & Ward, J.A. (1994). Age-associated differences in sensori-motor function and balance in community dwelling women. *Age and Ageing, 23*(6), 452-460.

Lord, S.R., & Webster, I.W. (1990). Visual field dependence in elderly fallers and non-fallers. *International Journal of Aging & Human Development, 31*(4), 267-277.

Mackintosh, S.F., Hill, K.D., Dodd, K.J., Goldie, P.A., & Culham, E.G. (2006). Balance score and a history of falls in hospital predict recurrent falls in the 6 months following stroke rehabilitation. *Archives of Physical Medicine and Rehabilitation, 87*(12), 1583-1589.

Mafauzy, M. (2000). The problems and challenges of the aging population of Malaysia. *Malaysian Journal of Medical Sciences, 7*(1), 1-3.

Mancini, M., & Horak, F.B. (2010). The relevance of clinical balance assessment tools to differentiate balance deficits. *European Journal of Physical and Rehabilitation Medicine, 46*(2), 239-248.

Mane, A.B., Sanjana, T., Patil, P.R., & Sriniwas, T. (2014). Prevalence and correlates of fear of falling among elderly population in urban area of Karnataka, India. *Journal of Mid-Life Health, 5*(3), 150-155.

Martins, E.F., de Menezes, L.T., de Sousa, P.H., de Araujo Barbosa, P.H., & Costa, A.S. (2012). Reliability of the Functional Reach Test and the influence of anthropometric characteristics on test results in subjects with hemiparesis. *NeuroRehabilitation, 31*(2), 161-169.

Masud, T., & Morris, R.O. (2001). Epidemiology of falls. *Age and Ageing, 30*(suppl 4), 3-7.

Means, K.M., Rodell, D.E., O'Sullivan, P.S., & Cranford, L.A. (1996). Rehabilitation of elderly fallers: pilot study of a low to moderate intensity exercise program. *Archives of Physical Medicine and Rehabilitation, 77*(10), 1030-1036.

Milat, A.J., Watson, W.L., Monger, C., Barr, M., Giffin, M., & Reid, M. (2011). Prevalence, circumstances and consequences of falls among community-dwelling older people: results of the 2009 NSW Falls Prevention Baseline Survey. *New South Wales Public Health Bulletin, 22*(3-4), 43-48. http://dx.doi.org/10.1071/NB10065

Moller, J., Hallqvist, J., Laflamme, L., Mattsson, F., Ponzer, S., Sadigh, S., & Engstrom, K. (2009). Emotional stress as a trigger of falls leading to hip or pelvic fracture. Results from the ToFa study - a case-crossover study among elderly people in Stockholm, Sweden. *BMC Geriatrics, 9*, 7. http://dx.doi.org/10.1186/1471-2318-9-7

Molnar, F.J., Hutton, B., & Fergusson, D. (2008). Does analysis using “last observation carried forward” introduce bias in dementia research? *Canadian Medical Association Journal, 179*(8), 751-753.

Muir, S.W. (2009). *Clinical assessment of balance to identify fall risk in community-dwelling older adults.* NR54320 (Ph.D.). The University of Western Ontario (Canada), Ann Arbor. Retrieved from http://search.proquest.com/docview/305109647?accountid=10382

Muir, S.W., Beauchet, O., Montero-Odasso, M., Annweiler, C., Fantino, B., & Speechley, M. (2013). Association of executive function impairment, history of falls and physical performance in older adults: a cross-sectional population-based study in eastern France. *The Journal of Nutrition, Health & Aging, 17*(8), 661-665.

Muir, S.W., Berg, K., Chesworth, B., Klar, N., & Speechley, M. (2010). Quantifying the magnitude of risk for balance impairment on falls in community-dwelling older adults: a systematic review and meta-analysis. *Journal of Clinical Epidemiology, 63*(4), 389-406.

Munro, B.H. (2004). *Statistical methods for health care research* (5th ed.). Philadelphia: Lippincott William & Wilkins.

Murtagh, E.M., Murphy, M.H., Murphy, N.M., Woods, C., Nevill, A.M., & Lane, A. (2015). Prevalence and correlates of physical inactivity in community-dwelling older adults in Ireland. *PLoS One, 10*(2), e0118293.

Nagano, H., Sparrow, W., & Begg, R.K. (2013). Biomechanical characteristics of slipping during unconstrained walking, turning, gait initiation and termination. *Ergonomics, 56*(6), 1038-1048.

Nandy, S., Parsons, S., Cryer, C., Underwood, M., Rashbrook, E., Carter, Y., . . . Feder, G. (2004). Development and preliminary examination of the predictive validity of the Falls Risk Assessment Tool (FRAT) for use in primary care. *Journal of Public Health, 26*(2), 138-143.

National Centers for Injury Prevention and Control. (2010). Web-based Injury Statistics Query and Reporting System (WISQARS) [online]. Accessed November 30, 2010.

Naylor, M.E., & Romani, W.A. (2006). Test-retest reliability of three dynamic tests obtained from active females using the NeuroCom Balance Master. *Journal of Sport Rehabilitation, 15*(4), 326-337.

NeuroCom. (2008). *Balance manager systems – Clinical Operation Guide* (8 ed.). Lawnfield Rd. Clackamas,OR: NeuroCom International Inc, .

Newstead, A.H., Hinman, M.R., & Tomberlin, J.A. (2005). Reliability of the Berg Balance Scale and Balance Master limits of stability tests for individuals with brain injury. *Journal of Neurologic Physical Therapy, 29*(1), 18-23.

Nitz, J.C., & Choy, N.L. (2004). The efficacy of a specific balance-strategy training programme for preventing falls among older people: a pilot randomised controlled trial. *Age and Ageing, 33*(1), 52-58.

Nitz, J.C., Choy, N.L., & Isles, R.C. (2003). Medial–lateral postural stability in community dwelling women over 40 years of age. *Clinical Rehabilitation, 17*(7), 765-767.

Nnodim, J.O., Strasburg, D., Nabozny, M., Nyquist, L., Galecki, A., Chen, S., & Alexander, N.B. (2006). Dynamic balance and stepping versus tai chi training to improve balance and stepping in at-risk older adults. *Journal of the American Geriatrics Society, 54*(12), 1825.

Nolan, M., Nitz, J., Choy, N.L., & Illing, S. (2010). Age-related changes in musculoskeletal function, balance and mobility measures in men aged 30-80 years. *The Aging Male, 13*(3), 194-201.

Nyman, S.R., & Victor, C.R. (2011). Older people's recruitment, sustained participation, and adherence to falls prevention interventions in institutional settings: a supplement to the Cochrane systematic review. *Age and Ageing, 40*(4), 430-436.

Nyman, S.R., & Victor, C.R. (2012). Older people's participation in and engagement with falls prevention interventions in community settings: an augment to the Cochrane systematic review. *Age and Ageing, 41*(1), 16-23.

Nyunt, M.S., Fones, C., Niti, M., & Ng, T.P. (2009). Criterion-based validity and reliability of the Geriatric Depression Screening Scale (GDS-15) in a large validation sample of community-living Asian older adults. *Aging & Mental Health, 13*(3), 376-382.

Nyunt, M.S., Lim, M.L., Yap, K.B., & Ng, T.P. (2012). Changes in depressive symptoms and functional disability among community-dwelling depressive older adults. *International Psychogeriatrics, 24*(10), 1633-1641.

O'Loughlin, J.L., Robitaille, Y., Boivin, J.-F., & Suissa, S. (1993). Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. *American Journal of Epidemiology, 137*(3), 342-354.

Oh, E., Hong, G.S., Lee, S., & Han, S. (2015). Fear of falling and its predictors among community-living older adults in Korea. *Aging Mental Health*, 1-10. http://dx.doi.org/10.1080/13607863.2015.1099034

Ong, F.S., Phillips, D.R., & Hamid, T.A. (Eds.). (2009). *Ageing in Malaysia* (Vols. 4).

Orendurff, M.S., Segal, A.D., Berge, J.S., Flick, K.C., Spanier, D., & Klute, G.K. (2006). The kinematics and kinetics of turning: limb asymmetries associated with walking a circular path. *Gait & Posture, 23*(1), 106-111.

Organisation, W.H. (2007). *WHO Global Report on Falls Prevention in Older Age*. Geneva, Switzerland: Retrieved from http://www.deslibris.ca/ID/220912

Ozalevli, S., Ilgin, D., Narin, S., & Akkoclu, A. (2011). Association between disease-related factors and balance and falls among the elderly with COPD: a cross-sectional study. *Aging Clinical and Experimental Research, 23*(5-6), 372-377.

Painter, J.A., Allison, L., Dhingra, P., Daughtery, J., Cogdill, K., & Trujillo, L.G. (2012). Fear of falling and its relationship with anxiety, depression, and activity engagement among community-dwelling older adults. *The American Journal of Occupational Therapy, 66*(2), 169-176.

Painter, J.A., Elliott, S.J., & Hudson, S. (2009). Falls in Community-dwelling Adults Aged 50 Years and Older Prevalence and Contributing Factors. *Journal of Allied Health, 38*(4), 201-207.

Panel on Prevention of Falls in Older Persons, A.G.S., & British Geriatrics, S. (2011). Summary of the Updated American Geriatrics Society/British Geriatrics Society Clinical Practice Guideline for Prevention of Falls in Older Persons. *Journal of the American Geriatrics Society, 59*(1), 148-157.

Park, J.H., Cho, H., Shin, J.H., Kim, T., Park, S.B., Choi, B.Y., & Kim, M.J. (2014). Relationship among fear of falling, physical performance, and physical characteristics of the rural elderly. *American Journal of Physical Medicine & Rehabilitation, 93*(5), 379-386.

Parkkari, J., Kannus, P., Palvanen, M., Natri, A., Vainio, J., Aho, H., . . . Jarvinen, M. (1999). Majority of hip fractures occur as a result of a fall and impact on the greater trochanter of the femur: a prospective controlled hip fracture study with 206 consecutive patients. *Calcified Tissue International, 65*(3), 183-187.

Peel, N.M. (2011). Epidemiology of falls in older age. *Canadian Journal on Aging, 30*(1), 7-19.

Perell, K.L., Nelson, A., Goldman, R.L., Luther, S.L., Prieto-Lewis, N., & Rubenstein, L.Z. (2001). Fall Risk Assessment Measures An Analytic Review. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56*(12), M761-M766.

Pickerill, M.L., & Harter, R.A. (2011). Validity and reliability of limits-of-stability testing: a comparison of 2 postural stability evaluation devices. *Journal of Athletic Training, 46*(6), 600-606.

Picorelli, A.M., Pereira, L.S., Pereira, D.S., Felicio, D., & Sherrington, C. (2014). Adherence to exercise programs for older people is influenced by program characteristics and personal factors: a systematic review. *Journal of Physiotherapy, 60*(3), 151-156.

Podsiadlo, D., & Richardson, S. (1991). The timed" Up & Go": a test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society, 39*(2), 142-148.

Powell, L.E., & Myers, A.M. (1995). The activities-specific balance confidence (ABC) scale. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 50*(1), M28-M34.

Prizer, L.P., Smith, M.L., Housman, J., & Ory, M.G. (2015). Depressive symptomology management and falls among middle aged and older adults. *Aging Mental Health*, 1-9. http://dx.doi.org/10.1080/13607863.2015.1021748

Prudham, D., & Evans, J. (1981). Factors associated with falls in the elderly: A community study. *Age and Ageing, 10*, 141 - 146.

Rashid, A., & Tahir, I. (2014). The Prevalence and Predictors of Severe Depression Among the Elderly in Malaysia. *Journal of Cross-Cultural Gerontology*, 1-17.

Rejeski, W.J., Axtell, R., Fielding, R., Katula, J., King, A.C., Manini, T.M., . . . Miller, M.E. (2013). Promoting physical activity for elders with compromised function: the lifestyle interventions and independence for elders (LIFE) study physical activity intervention. *Clinical Interventions in Aging, 8*, 1119-1131.

Rejeski, W.J., Miller, M.E., King, A.C., Studenski, S.A., Katula, J.A., Fielding, R.A., . . . Ashmore, J.A. (2007). Predictors of adherence to physical activity in the Lifestyle Interventions and Independence for Elders pilot study (LIFE-P). *Clinical Interventions in Aging, 2*(3), 485-494.

Ribeiro, F., & Oliveira, J. (2010). Effect of physical exercise and age on knee joint position sense. *Archives of Gerontology and Geriatrics, 51*(1), 64-67.

Richardson, J.K., & Hurvitz, E.A. (1995). Peripheral neuropathy: a true risk factor for falls. *J Gerontol A Biol Sci Med Sci, 50*(4), M211-215.

Richardson, K., Bennett, K., & Kenny, R.A. (2015). Polypharmacy including falls risk-increasing medications and subsequent falls in community-dwelling middle-aged and older adults. *Age and Ageing, 44*(1), 90-96.

Rizawati, M., & Mas Ayu, S. (2012). Home environment and fall at home among the elderly in Masjid Tanah Province. *Journal of Health and Translational Medicine, 11*(2)

Robertson, M.C., Campbell, A.J., Gardner, M.M., & Devlin, N. (2002). Preventing Injuries in Older People by Preventing Falls: A Meta-Analysis of Individual-Level Data. *Journal of the American Geriatrics Society, 50*(5), 905-911.

Rose, D.J., & Hernandez, D. (2010). The role of exercise in fall prevention for older adults. *Clinics in Geriatric Medicine, 26*(4), 607-631.

Rubenstein, L.Z. (2006). Falls in older people: epidemiology, risk factors and strategies for prevention. *Age and Ageing, 35 Suppl 2*, ii37-ii41.

Rubenstein, L.Z., Josephson, K.R., & Osterweil, D. (1996). Falls and fall prevention in the nursing home. *Clinics in Geriatric Medicine, 12*(4), 881.

Russell, M.A., Hill, K.D., Blackberry, I., Day, L.M., & Dharmage, S.C. (2008). The reliability and predictive accuracy of the falls risk for older people in the community assessment (FROP-Com) tool. *Age and Ageing, 37*(6), 634-639.

Ruziaton, H., Zaiton, A., Mohmad, S., & Hamid, T.A. (2006). *Healths Issues among the Aged* (1 ed.). Serdang: University Putra Malaysia.

Sato, Y., Kanoko, T., Satoh, K., & Iwamoto, J. (2005). Menatetrenone and vitamin D2 with calcium supplements prevent nonvertebral fracture in elderly women with Alzheimer's disease. *Bone, 36*(1), 61-68.

Sattin, R.W. (1992). Falls among older persons: a public health perspective. *Annual Review of Public Health, 13*, 489-508.

Sazlina, S., Krishnan, R., Shamsul, A., Zaiton, A., & Visvanathan, R. (2008). Prevalence of falls among older people attending a primary care clinic in Kuala Lumpur, Malaysia. *Jurnal Kesihatan Masyarakat, 14*(1), 11-16.

Scheffer, A.C., Schuurmans, M.J., van Dijk, N., van der Hooft, T., & de Rooij, S.E. (2008). Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. *Age and Ageing, 37*(1), 19-24. http://dx.doi.org/10.1093/ageing/afm169

Schoene, D., Lord, S.R., Delbaere, K., Severino, C., Davies, T.A., & Smith, S.T. (2013). A randomized controlled pilot study of home-based step training in older people using videogame technology. *PLoS One, 8*(3), e57734. http://dx.doi.org/10.1371/journal.pone.0057734

Schoene, D., Valenzuela, T., Toson, B., Delbaere, K., Severino, C., Garcia, J., . . . Lord, S.R. (2015). Interactive Cognitive-Motor Step Training Improves Cognitive Risk Factors of Falling in Older Adults - A Randomized Controlled Trial. *PLoS One, 10*(12), e0145161. http://dx.doi.org/10.1371/journal.pone.0145161

Schulz, K.F., Altman, D.G., & Moher, D. (2010). CONSORT 2010 statement: Updated guidelines for reporting parallel group randomised trials. *Journal of Pharmacology & Pharmacotherapeutics, 1*(2), 100-107.

Sedgman, R., Goldie, P., & Iansek, R. (1994). *Development of a measure of turning during walking.* Paper presented at the Advancing Rehabilitation: Proceedings of the Inaugural Conference of the Faculty of Health Sciences La Trobe University, Victoria,Australia

Segal, A., Orendurff, M., Czerniecki, J., Shofer, J., & Klute, G. (2008a). Local dynamic stability in turning and straight-line gait. *Journal of Biomechanics, 41*(7), 1486 - 1493.

Segal, A.D., Orendurff, M.S., Czerniecki, J.M., Shofer, J.B., & Klute, G.K. (2008b). Local dynamic stability in turning and straight-line gait. *J Biomech, 41*(7), 1486-1493.

Segev-Jacubovski, O., Herman, T., Yogev-Seligmann, G., Mirelman, A., Giladi, N., & Hausdorff, J.M. (2011). The interplay between gait, falls and cognition: can cognitive therapy reduce fall risk? *Expert Review of Neurotherapeutics, 11*(7), 1057-1075.

Shaffer, S.W., & Harrison, A.L. (2007). Aging of the somatosensory system: a translational perspective. *Physical Therapy Forum, 87*(2), 193-207.

Sherrington, C., Lord, S., & Close, J. (2008). Best practice recommendations for physical activity to prevent falls in older adults. *North Sydney: NSW Department of Health,*

Sherrington, C., Tiedemann, A., Fairhall, N., Close, J.C., & Lord, S.R. (2011). Exercise to prevent falls in older adults: an updated meta-analysis and best practice recommendations. *New South Wales Public Health Bulletin, 22*(3-4), 78-83.

Shi, J., Zhou, B.Y., Tao, Y.K., Yu, P.L., Zhang, C.F., Qin, Z.H., & Sun, Z.Q. (2014). Incidence and associated factors for single and recurrent falls among the elderly in an urban community of Beijing. *Biomed Environ Sci, 27*(12), 939-949.

Shigematsu, R., Okura, T., Nakagaichi, M., Tanaka, K., Sakai, T., Kitazumi, S., & Rantanen, T. (2008). Square-stepping exercise and fall risk factors in older adults: a single-blind, randomized controlled trial. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 63*(1), 76-82.

Shin, K.R., Kang, Y., Hwang, E.H., & Jung, D. (2009a). The prevalence, characteristics and correlates of falls in Korean community-dwelling older adults. *International Nursing Review, 56*(3), 387-392. http://dx.doi.org/10.1111/j.1466-7657.2009.00723.x

Shkuratova, N., Morris, M.E., & Huxham, F. (2004). Effects of age on balance control during walking. *Archives of Physical Medicine and Rehabilitation, 85*(4), 582-588.

Shumway-Cook, A., Brauer, S., & Woollacott, M. (2000). Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Physical Therapy Forum, 80*(9), 896-903.

Shumway-Cook, A., & Horak, F.B. (1986). Assessing the influence of sensory interaction of balance. Suggestion from the field. *Physical Therapy, 66*(10), 1548-1550.

Shumway-Cook, A., Silver, I.F., LeMier, M., York, S., Cummings, P., & Koepsell, T.D. (2007). Effectiveness of a community-based multifactorial intervention on falls and fall risk factors in community-living older adults: a randomized, controlled trial. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 62*(12), 1420-1427.

Shyu, Y.I.L., Liang, J., Wu, C.C., Su, J.Y., Cheng, H.S., Chou, S.W., . . . Tseng, M.Y. (2010). Two year effects of interdisciplinary intervention for hip fracture in older Taiwanese. *Journal of the American Geriatrics Society, 58*(6), 1081-1089.

Sibley, K.M., Straus, S.E., Inness, E.L., Salbach, N.M., & Jaglal, S.B. (2011). Balance assessment practices and use of standardized balance measures among Ontario physical therapists. *Physical Therapy Forum, 91*(11), 1583-1591.

Silsupadol, P., Siu, K.C., Shumway-Cook, A., & Woollacott, M.H. (2006). Training of balance under single- and dual-task conditions in older adults with balance impairment. *Physical Therapy Forum, 86*(2), 269-281.

Simpson, J.M., Worsfold, C., Reilly, E., & Nye, N. (2002). A Standard Procedure for Using TURN180: Testing dynamic postural stability among elderly people. *Physiotherapy, 88*(6), 342-353.

Siong, K.H., Kwan, M.M., Lord, S.R., Lam, A.K., Tsang, W.W., & Cheong, A.M. (2016). Fall risk in Chinese community-dwelling older adults: A physiological profile assessment study. *Geriatrics & Gerontology International, 16*(2), 259-265.

Sohng, K.-Y., Moon, J.-S., Song, H.-H., Lee, K.-S., & Kim, Y.-S. (2003). Fall prevention exercise program for fall risk factor reduction of the community-dwelling elderly in Korea. *Yonsei Medical Journal, 44*(5), 883.

Sohng, K.Y., Moon, J.S., Song, H.H., Lee, K.S., & Kim, Y.S. (2004). Risk factors for falls among the community-dwelling elderly in Korea. *Taehan Kanho Hakhoe Chi, 34*(8), 1483-1490.

Sophonratanapokin, B., Sawangdee, Y., & Soonthorndhada, K. (2012). Effect of the living environment on falls among the elderly in Thailand. *The Southeast Asian Journal of Tropical Medicine and Public Health, 43*(6), 1537-1547.

Speechley, M. (2011). Knowledge translation for falls prevention: The view from Canada. *Journal of Safety Research, 42*(6), 453-459.

Steadman, J., Donaldson, N., & Kalra, L. (2003). A randomized controlled trial of an enhanced balance training program to improve mobility and reduce falls in elderly patients. *Journal of the American Geriatrics Society, 51*(6), 847.

Steffen, T.M., Hacker, T.A., & Mollinger, L. (2002). Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Physical Therapy, 82*(2), 128-137.

Stevens, J.A., Ballesteros, M.F., Mack, K.A., Rudd, R.A., DeCaro, E., & Adler, G. (2012). Gender differences in seeking care for falls in the aged Medicare population. *American Journal of Preventive Medicine, 43*(1), 59-62.

Stevens, J.A., Corso, P., Finkelstein, E., & Miller, T. (2006). The costs of fatal and non-fatal falls among older adults. *Injury Prevention, 12*(5), 290-295.

Stevens, J.A., Mack, K.A., Paulozzi, L.J., & Ballesteros, M.F. (2008). Self-reported falls and fall-related injuries among persons aged>or=65 years--United States, 2006. *Journal of Safety Research, 39*(3), 345-349.

Stevens, J.A., & Rudd, R.A. (2013). The impact of decreasing US hip fracture rates on future hip fracture estimates. *Osteoporosis International, 24*(10), 2725-2728.

Stevens, J.A., & Sogolow, E.D. (2005). Gender differences for non-fatal unintentional fall related injuries among older adults. *Injury Prevention :*

Journal of the International Society for Child and Adolescent Injury Prevention, 11(2), 115-119. http://dx.doi.org/10.1136/ip.2004.005835

Stewart, W.J., Kowal, P., Hestekin, H., O'Driscoll, T., Peltzer, K., Yawson, A., . . . Chatterji, S. (2015). Prevalence, risk factors and disability associated with fall-related injury in older adults in low- and middle-incomecountries: results from the WHO Study on global AGEing and adult health (SAGE). *BMC Medicine, 13*, 147. http://dx.doi.org/10.1186/s12916-015-0390-8

Suttanon, P., Hill, K.D., Dodd, K.J., & Said, C.M. (2011). Retest reliability of balance and mobility measurements in people with mild to moderate Alzheimer's disease. *International Psychogeriatrics 23*(7), 1152-1159.

Suttanon, P., Hill, K.D., Said, C.M., Logiudice, D., Lautenschlager, N.T., & Dodd, K.J. (2012). Balance and mobility dysfunction and falls risk in older people with mild to moderate Alzheimer disease. *American Journal of Physical Medicine & Rehabilitation, 91*(1), 12-23.

Suzuki, T., Kim, H., Yoshida, H., & Ishizaki, T. (2004). Randomized controlled trial of exercise intervention for the prevention of falls in community-dwelling elderly Japanese women. *Journal of Bone and Mineral Metabolism, 22*(6), 602-611.

Talbot, L., Musiol, R., Witham, E., & Metter, E.J. (2005). Falls in young, middle-aged and older community dwelling adults: perceived cause, environmental factors and injury. *BMC Public Health, 5*(1), 86.

Tan, P.J., Khoo, E.M., Chinna, K., Hill, K.D., Poi, P.J., & Tan, M.P. (2014). An individually-tailored multifactorial intervention program for older fallers in a middle-income developing country: Malaysian Falls Assessment and Intervention Trial (MyFAIT). *BMC Geriatrics, 14*, 78. http://dx.doi.org/10.1186/1471-2318-14-78

Tedeiksaar, R. (2010). *Falls in older people* (4 ed.). Baltimore: Health Professions Press.

Tengku Aizan, H. (2012). Population Ageing: Past, Present and Future Trends. In H. Tengku Aizan, S. Husna & Z. A. Siti Farra (Eds.), *Profile of Older*

Malaysians: Current and Future Challenges. Serdang: Universit Putra Malaysia Press.

Tennstedt, S., Howland, J., Lachman, M., Peterson, E., Kasten, L., & Jette, A. (1998). A randomized, controlled trial of a group intervention to reduce fear of falling and associated activity restriction in older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 53*(6), 384-392.

Thiamwong, L., Thamarpirat, J., Maneesriwongul, W., & Jitapunkul, S. (2008). Thai falls risk assessment test (Thai-FRAT) developed for community-dwelling Thai elderly. *Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 91*(12), 1823-1831.

Thigpen, M.T., Light, K.E., Creel, G.L., & Flynn, S.M. (2000). Turning difficulty characteristics of adults aged 65 years or older. *Physical Therapy, 80*(12), 1174-1187.

Tideiksaar, R. (2002). *Falls in older people: Prevention and Management.* Baltimore: MD: Health Professions Press.

Tiedemann, A., Lord, S., & Sherrington, C. (2012). The Quickscreen Tool - A validated fall risk assessment, developed and implemented in Australia for use in primary care. *Injury Prevention, 18*(Suppl 1), A56-A56.

Tinetti, M.E. (2003). Preventing Falls in Elderly Persons. *New England Journal of Medicine, 348*(1), 42-49.

Tinetti, M.E., Speechley, M., & Ginter, S.F. (1988). Risk factors for falls among elderly persons living in the community. *The New England Journal of Medicine, 319*(26), 1701-1707.

Tinetti, M.E., & Williams, C.S. (1998). The effect of falls and fall injuries on functioning in community-dwelling older persons. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 53*(2), 112-119.

Tinetti, M.E., Williams, T.F., & Mayewski, R. (1986). Fall risk index for elderly patients based on number of chronic disabilities. *The American Journal of Medicine, 80*(3), 429-434.

Tovell, A., & Harrison, J.E. (2013). *Trends in hospitalisations due to falls by older people, Australia 1999-00 to 2010-11*. (Injury research and statistictics no. 84. Cat. no. INJCAT 160). Canberra: Australian Institute of Health and Welfare.

Tovell, A., Harrison, J.E., & Pointer, S. (2014). *Hospitalised injury in older Australians, 2011–12*. (Injury research and statistictics no. 90. Cat. no. INJCAT 166). Canberra: Australian Instituite of Health and Welfare.

Ullmann, G., Williams, H.G., Hussey, J., Durstine, J.L., & McClenaghan, B.A. (2010). Effects of Feldenkrais exercises on balance, mobility, balance confidence, and gait performance in community-dwelling adults age 65 and older. *Journal of Alternative and Complementary Medicine, 16*(1), 97.

Vellas, B.J., Wayne, S.J., Romero, L.J., Baumgartner, R.N., & Garry, P.J. (1997). Fear of falling and restriction of mobility in elderly fallers. *Age and Ageing, 26*(3), 189-193.

Verbaken, J., & Johnston, A. (1986). Population norms for edge contrast sensitivity. *American Journal of Optometry and Physiological Optics, 63*(9), 724.

Wada, T., Ishine, M., Sakagami, T., Kita, T., Okumiya, K., Mizuno, K., . . . Matsubayashi, K. (2005). Depression, activities of daily living, and quality of life of community-dwelling elderly in three Asian countries: Indonesia, Vietnam, and Japan. *Archives of Gerontology and Geriatrics, 41*(3), 271-280.

Wang, C., Sheu, C., & Protas, E. (2009). Test-retest reliability and measurement errors of six mobility tests in the community-dwelling elderly. *Asian Journal of Gerontolology & Geriatric, 4*, 8-13.

Weirich, G., Bemben, D.A., & Bemben, M.G. (2010). Predictors of balance in young, middle-aged, and late middle-aged women. *Journal of Geriatric Physical Therapy, 33*(3), 110-117.

Whitney, S.L., Wrisley, D.M., Marchetti, G.F., Gee, M.A., Redfern, M.S., & Furman, J.M. (2005). Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the Five-Times-Sit-to-Stand Test. *Physical Therapy, 85*(10), 1034-1045.

WHO. (2012). *Falls. Fact sheet N 344 Media Center*

Wickremaratchi, M.M., & Llewelyn, J.G. (2006). Effects of ageing on touch. *Postgraduate Medical Journal, 82*(967), 301-304.

Williams, S.B., Brand, C.A., Hill, K.D., Hunt, S.B., & Moran, H. (2010). Feasibility and outcomes of a home-based exercise program on improving balance and gait stability in women with lower-limb osteoarthritis or rheumatoid arthritis: a pilot study. *Archives of Physical Medicine and Rehabilitation, 91*(1), 106.

Woo, J., Hong, A., Lau, E., & Lynn, H. (2007). A randomised controlled trial of Tai Chi and resistance exercise on bone health, muscle strength and balance in community-living elderly people. *Age and Ageing, 36*(3), 262-268.

Woods, D.L., Wyma, J.M., Yund, E.W., Herron, T.J., & Reed, B. (2015). Age-related slowing of response selection and production in a visual choice reaction time task. *Frontiers in Human Neuroscience, 9*, 193.

Woolcott, J.C., Richardson, K.J., Wiens, M.O., Patel, B., Marin, J., Khan, K.M., & Marra, C.A. (2009). Meta-analysis of the impact of 9 medication classes on falls in elderly persons. *Arch Intern Med, 169*(21), 1952-1960.

Woollacott, M.H., Shumway-Cook, A., & Nashner, L.M. (1986). Aging and posture control: changes in sensory organization and muscular coordination. *International Journal of Aging & Human Development, 23*(2), 97-114.

World Health Organization. (2012). *Falls. Fact sheet N 344*.

Wright, R.L., Peters, D.M., Robinson, P.D., Sitch, A.J., Watt, T.N., & Hollands, M.A. (2012). Differences in axial segment reorientation during standing turns predict multiple falls in older adults. *Gait & Posture, 36*(3), 541-545.

Yamada, M., Tanaka, B., Nagai, K., Aoyama, T., & Ichihashi, N. (2010). Trail-walking exercise and fall risk factors in community-dwelling older adults: preliminary results of a randomized controlled trial. *Journal of the American Geriatrics Society, 58*(10), 1946-1951. http://dx.doi.org/10.1111/j.1532-5415.2010.03059.x

Yamaguchi, T., Yano, M., Onodera, H., & Hokkirigawa, K. (2012). Effect of turning angle on falls caused by induced slips during turning. *Journal of Biomechanics, 45*(15), 2624-2629.

Yang, X.J., Hill, K., Moore, K., Williams, S., Dowson, L., Borschmann, K., . . . Dharmage, S.C. (2012). Effectiveness of a targeted exercise intervention in reversing older people's mild balance dysfunction: A randomized controlled trial. *Physical Therapy, 92*(1), 24-37.

Yardley, L., & Smith, H. (2002). A prospective study of the relationship between feared consequences of falling and avoidance of activity in community-living older people. *The Gerontologist, 42*(1), 17-23.

Yesavage, J.A., & Sheikh, J.I. (1986). Geriatric Depression Scale (GDS). *Clinical Gerontologist, 5*(1-2), 165-173.

Yin Fah, B.C., Hamid, T.A., Masud, J., & Paim, L. (2010). Predictors of Financial Dependency in Old Age in Peninsular Malaysia: An Ethnicity Comparison. *Asian Social Science, 6*(6), p54.

Zecevic, A.A. (2006). *A human factors perspective of falls in older adults.* NR30414 (Ph.D.). The University of Western Ontario (Canada), Ann Arbor. Retrieved from http://search.proquest.com/docview/304940318?accountid=10382

Zecevic, A.A., Salmoni, A.W., Speechley, M., & Vandervoort, A.A. (2006). Defining a fall and reasons for falling: comparisons among the views of seniors, health care providers, and the research literature. *Gerontologist, 46*(3), 367-376. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16731875

Zhang, J., Liu, J., Shao, Q., & Mao, Y. (2005). Investigation on falling down among the school retired elderly and its influencing factors. *China Journal of Clinical Rehabilitation, 9*, 184-185.

Ziere, G., Dieleman, J.P., Hofman, A., Pols, H.A., van der Cammen, T.J., & Stricker, B.H. (2006). Polypharmacy and falls in the middle age and elderly population. *British Journal of Clinical Pharmacology, 61*(2), 218-223.

APPENDICES

Asmidawati et al. BMC Geriatrics 2014, 14:100
http://www.biomedcentral.com/1471-2318/14/100

BMC Geriatrics

STUDY PROTOCOL **Open Access**

Home based exercise to improve turning and mobility performance among community dwelling older adults: protocol for a randomized controlled trial

Ashari Asmidawati[1,2*], Tengku Aizan Hamid[2], Rizal M Hussain[2] and Keith D Hill[1,3]

Abstract

Background: Turning is a common activity for older people, and is one of the activities commonly associated with falls during walking. Falls that occur while walking and turning have also been associated with an increased risk of hip fracture in older people. Despite the importance of stability during turning, there has been little focus on identifying this impairment in at risk older people, or in evaluating interventions aiming to improve this outcome. This study will evaluate the effectiveness of a 16 week tailored home based exercise program in older adults aged (50 years and above) who were identified as having unsteadiness during turning.

Methods/Design: A single blind randomized controlled trial will be conducted, with assessors blind to group allocation. Study participants will be aged 50 years and above, living in the community and have been identified as having impaired turning ability [outside of age and gender normal limits on the Step Quick Turn (180 degree turn) task on the Neurocom® Balance Master with long plate]. After a comprehensive baseline assessment, those classified as having balance impairment while turning will be randomized to intervention or control group. The intervention group will receive a 16 week individualized balance and strength home exercise program, based on the Otago Exercise Program with additional exercises focused on improving turning ability. Intervention group will attend four visit to the assessment centre over 16 weeks period, for provision, monitoring, modification of the exercise and encourage ongoing participation. Participants in the control group will continue with their usual activities. All participants will be re-assessed on completion of the 16 week program. Primary outcome measures will be the Step Quick Turn Test and Timed-Up and Go test. Secondary outcomes will include other clinical measures of balance, psychological aspects of falls, incidence of falls and falls risk factors.

Discussion: Results of this study will provide useful information for clinicians on the types of exercises to improve turning ability in older people with increased falls risk and the effectiveness of these exercises in improving outcomes.

Trial Registration: ACTRN12613000855729.

Background

Successful ambulation in one's daily activities is dependent on the ability to maintain balance during navigation. Balance is defined as the "harmonious and contextually appropriate interplay of stability and mobility of the body with respect to its Base of Support" [1]. Impairments in balance, gait and lower limb strength are important factors associated with reduced mobility and dependency in activities of daily living among older people [2]. Balance performance results from a complex interaction between sensory and musculoskeletal systems requiring constant adjustment of muscle activity and joint position sense and other sensory information to retain the centre of mass of the body over the base of support [3]. In addition, disorders of motor output such as impaired (efferent) reaction time, reduced muscle strength and other factors such as pain can impair balance control [4]. Furthermore,

* Correspondence: aashari@student.curtin.edu.au
[1]School of Physiotherapy and Exercise Science, Faculty of Health Sciences, Curtin University, Perth, Western Australia 6845, Australia
[2]Institute of Gerontology, Universiti Putra Malaysia, Serdang, Selangor, Malaysia
Full list of author information is available at the end of the article

BioMed Central

Appendix 1: A protocol paper

UPM UNIVERSITI PUTRA MALAYSIA

INSTITUTE OF GERONTOLOGY

LA TROBE UNIVERSITY AUSTRALIA

SCHOOL OF PHYSIOTHERAPY

Need volunteers as participants for research study...

Study title

FALLS PREVALENCE AND RISK ASSESSMENT AMONG COMMUNITY DWELLING OLDER ADULTS (AGED 50 YEARS AND ABOVE) IN MALAYSIA

Introduction

You are invited to participate in the research project entitled **"Falls Prevalence And Risk Assessment Among Community Dwelling Older Adults (Aged 50 Years And Above) in Malaysia."** The purpose of the study is to investigate how common falls are, and to identify risk factors of falls among older Malaysians.

What will you have to do?

Your participation in this study is completely voluntary. Should you agree to participate in this study, you will be asked to undergo an assessment of balance and a face-to-face interview regarding history of fall and fall risk assessment. The duration of the assessment will take approximately 90 minutes.

Participant criteria?

- **Age 50 years and above**
- **Able to stand and walk independently**
- **Able to understand and communicate in Malay or English**
- **Community dwelling**

Are there any benefits?

Participants will not derive any direct benefit from participation in the study. However, the information gained from your participation will help us better understand falls risk in older Malaysians, and this will hopefully assist in the development of policies, programs, facilities or services through academic input that will benefit the general public. Participants will receive a small token of thanks from the researcher. No medications will be given in this assessment.

Are there any risks?

We expect that any risks (if at all) or any inconvenience during the assessment will be very minor or minimal. Safety procedures will be followed to avoid any potential risk of injuries or accident happen during assessment. The procedures of this study have been reviewed and received Ethical Approval by the La Trobe University Faculty of Health Sciences Human Research Ethics Committee and the Human Ethics Committee of Universiti Putra Malaysia.

Location of Assessment?

The assessment and interview will be held at Gerontology Laboratory, Level 4, Block D, Faculty of Medicine and Health Science, Universiti Putra Malaysia, Serdang, Selangor.

Contact person?

Should you be interested to participate / have further enquiries about the study, please feel free to contact **Mrs. Asmidawati Ashari** at **013-6197278** or e-mail: **aashari@students.latrobe.edu.au** or **asmidawati@gmail.com**

Appendix 2: Recruitment Flyer

Aged 50 years above and feel unstable when walking or turning ???

Then, you're invited to join us...

Project Title:
Fall risk assessment and effectiveness of home-based exercise on balance and functional mobility performance among older Malaysian aged 50 years and above

If you agree to participate in this study, you will have an assessment of your balance ability under-taken. Depending on the outcome of this assess-ment, you may be invited to also participate in a 16 week exercise program that can be conducted in your home, or to continue with your usual activities.

Curtin University

School of Physiotherapy,
Faculty of Health Sciences

UPM
UNIVERSITI PUTRA MALAYSIA

INSTITUT GERONTOLOGI

Venue:
Gerontology Laboratory
Level 4, Blok D,
Faculty of Health Sciences,
UPM.

Contact Us:

Phone: 019-9367278 (Asmida)
Phone: 03-89472756
(Siti Norehan)
E-mail: asmidawati@ gmail.com.

Appendix 3:Recruitement poster

Curtin University

Faculty of Health Sciences
School of Physiotherapy
Telephone : +61 8 9266 3618
Facsimile : +61 8 9266 3699

UPM
UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

JAWATANKUASA ETIKA UNIVERSITI UNTUK PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA,
43400 UPM SERDANG,
SELANGOR, MALAYSIA

PARTICIPANT INFORMATION SHEET

You are being invited to take part in this study. Before agreeing to participate in this study, it is important for you to read and understand the following explanation of the proposed study. It describes the procedures, benefit, risks and discomforts of this study. It also describes your right to withdraw from the study at any time. Please read the following information carefully and do not hesitate to clarify any questions you may have with researcher.

TITLE OF THE STUDY

FALL RISK ASSESSMENT AND EFFECTIVENESS OF HOME BASED EXERCISE ON BALANCE AND FUNCTIONAL MOBILITY AMONG OLDER MALAYSIAN AGED 50 YEARS AND ABOVE.

WHO WILL CONDUCT THIS STUDY?

This study will be conducted by Asmidawati Ashari, as part of her PhD, enrolled through the School of Physiotherapy, Curtin University, Perth, Western Australia.Other researchers involved in the study are Professor Keith Hill (Head of School Physiotherapy, Curtin University, Australia) and Professor Tengku Aizan Hamid (Director, Institute of Gerontology, Universiti Putra Malaysia).

WHAT IS THE PURPOSE OF THIS STUDY?

Balance problems and falls are common among older people.Previous researchhas shown that exercise programs which incorporate balance and strengthening exercises can reduce risk of falls. Recent research we have conducted at Universiti Putra Malaysia indicated that difficulties with turning were associated with risk of falling. The purpose of this study is to investigate the effectiveness of a 16 week home exercise program that includes exercises aiming to improve turning ability and function among olderpeople with a turning difficulties.

WHO SHOULD ENTER THIS STUDY?

- Community dwelling older adult volunteers aged 50 years and above;
- Identified as having unsteadiness during turning through a detailed balance assessment;
- Able to walk independently in the community with no walking aid or single point stick only.

Appendix 4: Participant information sheet

DO I NEED TO TAKE PART?

Your participation in this study is entirely voluntary. If you choose not to participate in this study, we will completely respect your decision and this will have no effect on the services or benefits you are currently receiving. If you decide to take part, you will need to sign a consent form and we will provide you with a copy of this for your records.

CAN I WITHDRAW FROM THIS STUDY?

You may withdraw from the study at any time, including during the assessment or the exercise program. While your participation is very valuable to us, it is even more important that you make the decisions that are right for you. Our researchers will support your decision if you decide you can't continue participating in this study. There are no penalty, charges or any legal actions that will be taken against you if you withdraw. If you wish to withdraw from the study, please inform the researchers and fill inthe withdrawal form for our reference.

WHAT WILL YOU HAVE TO DO?

If you have expressed an interest to take part in this study, we will contact you by phone to check a few details to confirm your eligibility for participation, including if you are experiencing any difficulties turning. If you are eligible and still happy to take part, we will arrange an appointment for you to attend an initial assessment at the Gerontology Laboratory, Faculty of Health Science, UniversitiPutra Malaysia. Details of the study will be explained, and you will be asked to sign a consent form. You will then undertake an assessment, in which your balance and mobility will be assessed using some clinical measurements commonly used by physiotherapists, as well as some measurements using a force platform (a computerised machine that also measures balance), and some questionnaires about your general health, activity, and confidence in mobility. For safety, you will wear a safety jacket and harness during several of the force platform balance assessments. Part of the assessment which measures turning ability will be used to determine your turning ability. If you are identified as having difficulties with turning on this assessment, you will be eligible to participate in the main part of this study.

If you are eligible to participate in this study, you will be randomly (by chance) allocated to one of two groups. Participants in one group will be asked to undertake a 16 week exercise program at home, while participants in the other group will be asked to continue with their usual activities for the next 16 weeks (see details below).

What you will do if you are allocated to the exercise group?

1. attend the detailed balance assessment for an initial assessment, and a repeat assessment 16 weeks later.
2. complete a home based exercise program (provided by the researchers) 4 times a week (at least 20-30 minutes per session). You will be provided with a booklet with illustrations and instructions for the exercise program.
3. visit the assessment laboratory at Universiti Putra Malaysia for three (3) additional visits (after week 3, 6 and 9) to review your progress with the exercise

Appendix 4: Participant information sheet.

program, and to modify the exercises if required.

4. complete your exercise diary (ticking exercises done in each exercise session).
5. you will receive four (4) phone calls during the 16 weeks from a separate researcher to ask whether you had any falls in the preceding 3 weeks.

A) What you will do if allocated to the usual activity group?

1. attend the detailed balance assessment for an initial assessment, and a repeat assessment 16 weeks later.
2. continue with your usual activity.
3. you will receive four (4) phone calls during the 16 weeks from a researcher to ask whether you had any falls in the preceding 3 weeks.

It is recommended to wear comfortable clothes/ attire when attending the assessment session.Questionnaires will be interspersed between the measures of balance and mobility.This assessment will take approximately 90 to 120 minutes duration. You will be able to rest between tests if required.

We estimate that there will be a total of 68 participants included in this study, who will be randomly allocated into the exercise and usual activity groups.

ARE THERE ANY COSTSOR REIMBURSEMENT?

Participation in the study does not involve any costs for you. You will not be charged for any assessment, treatment and consultation that you receive as part of this study.

You will receive amount of RM 20 as an honorium for study related visit costs (to assist with any travel costs etc) and a woven bag as a token of appreciation for your participation.

ARE THERE ANY RISKS?

There is a minimal physical risk / emotional risk where you may feel unsteady during the standing balance tests. To ensure safety during the force platform standing tests, a safety jacket and harness will be attached to an overhead rail, which will steady you if you start to overbalance. During all other clinical and force platform tests, you will be closely supervised by the researcher. The researchers involvedin this study have received training by Professor Hill in the balance assessment procedures and exercise prescription. These tests of balance and mobility have been used safely in Professor Hill's Melbourne gait laboratories in over 1000 older participants over the past 15 years, including some with clinical problems affecting their balance performance such as stroke, Parkinson's disease and arthritis, but have been performed safely, without any incidents. The clinical tests being used are also routinely used by physiotherapists safely in clinical practice, with older people with multiple health problems.

The exercise program on which the exercises used in this study are largely based (the Otago Exercise program) has been shown to be a safe, effective, practical program for older people.

Appendix 4: (continued). Participant information sheet

The procedures of this study also have been reviewed and received approval by the Curtin University Human Research Ethics Committee in accordance with the National Health and Medical Research Council (NHMRC) National Statement in Human Research; and Universiti Putra Malaysia Ethics Committee.

We expect that any risks (if at all) or any inconveniences will be minor. In the unlikely situation where you may experience an injury or illness associated with participation in this project, the researcher will assist you in seeking appropriate health care or other care and any compensation for costs incurred available through personal and accidents insurance.

WHAT WILL BE POSSIBLE BENEFITS OF PARTICIPATION IN THE STUDY?

(a) TO YOU AS THE PARTICIPANT?

All participants will receive a brief summary of the assessment report of your balance and mobility at the end of the project, that you can discuss with your doctor or other health professional. If you are allocated to the exercise group, you may achieve improvement in your balance and mobility.

(b) TO THE INVESTIGATOR?

The results will help the researchers to determine whether this modified exercise program with a focus on improving turning ability is effective in improving performance on this important activity. If results are positive, this information may be useful to physiotherapists and other health professionals working with older people at risk of falling, to reduce risk of falls, particularly those associated with turning.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?

The results of this study will be used as a part of Asmidawati Ashari's PhD thesis, and may be published in a research journal or presented at one or more relevant conferences. In all of these, only group data will be presented, no data that will identify individual participants will be presented.

WILL THE INFORMATION AND MY IDENTITY REMAIN CONFIDENTIAL?

Yes. All informationobtained through this study will remain confidential. Participant identifying data will only be used for contact purposes and will not be included on the electronic database. Instead, participants will be allocated a code number, and this will be used in place of identifying details on the electronic database. Participant contact details and an identification code will be kept in a separate locked filing cabinet, and only the research team will have access.

Data will be recorded on paper based forms, and will then be scanned to the electronic database. Electronic files will be stored on a password protected computer network at the Institute of Gerontology at UniversitiPutra Malaysia, and only members of the research team will have access to the paper or electronic files. All written files will be stored in a locked filing cabinet in the office of AsmidawatiAshari at the Institute of Gerontology, Universiti Putra Malaysia. Data will be stored for 5 years after publication.

Appendix 4: (continued). Participant information sheet

WHO SHOULD I CONTACT IF I HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If there are any further questions, complaints or feedback about the research, participants may submit in writing or verbally to the researcher by telephone, email or write to the following addresses:

Student Investigator. Mrs. Asmidawati Ashari PhD Student, School of Physiotherapy, Curtin University, Bentley, Perth WA 6102 Email: aashari@students.curtin.edu.au **Local address (Malaysia)** Mrs. Asmidawati Ashari Level 3, Institute of Gerontology, University Putra Malaysia, Serdang 43400 Selangor, Malaysia. Mobile Phone. No: 019-9367278 Phone. No: 603-89472735 Fax: 603-89472744 Email: asmidawati@gmail.com	**Main Supervisor** Professor Keith Hill Head, School of Physiotherapy Curtin University, Perth, WA 6102 Phone. No:+61 92663618 Fax:+61 92663699 e-mail: Keith.Hill@curtin.edu.au **Associate Supervisor** Professor Tengku Aizan Hamid Director, Institute of Gerontology Universiti Putra Malaysia. 43400 Serdang, Selangor, Malaysia Phone. No: +603-89472750 Fax:+603-89472744 e-mail: aizan@putra.upm.edu.my

You may also contact the secretary of the Ethics Committees that have approved this project if you have specific concerns on ethical or complaints about the conduct of the research (contact details below).

ETHICS COMMITTEE APPROVAL

This study has been approved under Curtin University's process for lower-risk Studies (Approval Number PT231/2013. This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21).

For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 61 8 9266 9223 or by emailing hrec@curtin.edu.au).

The study has also been approved by University Putra Malaysia Ethics Committee (Reference Number IG_April Curtin (13) 04).

If you agree to participate in this study please sign on the participant's consent form.

Thank you for considering taking part in our study

Appendix 4: continued Participant information sheet

Curtin University

Faculty of Health Sciences
School of Physiotherapy
Telephone +61 8 9266 3618
Facsimile +61 8 9266 3699

UPM
JAWATANKUASA ETIKA UNIVERSITI UNTUK PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400
UPM SERDANG,
SELANGOR, MALAYSIA

Fall Risk Assessment And Effectiveness Of Home Based Exercise On Balance And Functional Mobility Among Older Malaysian Aged 50 Years and Above.

CONSENT FORM FOR PARTICIPANT

I have read the Information Sheet concerning this project and understand what it is all about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I acknowledge that:

1. My participation in the project is entirely voluntary.
2. I have been informed of the details of the procedures associated with participation in this project, including the anticipated length of time it will take, the frequency with which the procedures will be performed, and an indication of any discomfort, which may be expected.
3. I understand that the results of the study may be published, but no information will be published which can identify me.
4. I understand that I can withdraw at any time without prejudice.
5. I understand that I will be given a signed copy of this patient information sheet and consent form. I am not giving up my legal rights by signing this consent form.
6. I understand that the intervention will be stopped if it should appear harmful to me. I know whom to contact if I have any side effects to the study or have any questions.
7. I agree to participate in the study as outlined to me.

Name of Participant: ....

.... (Signature of participant)

.... (Date)

Consent Form.Ver.2.0/May 2013 Page 1/2

Appendix 5: Consent Form

Curtin University

UPM

JAWATANKUASA ETIKA UNIVERSITI UNTUK PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400
UPM SERDANG,
SELANGOR, MALAYSIA

Statement by Investigator

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have had the opportunity to contact me prior to consenting to participate in this project.

Name of Researcher : ……………………………………………………………

……………………………………………
(Signature of researcher)

……………………………………
(Date)

This project has been reviewed and approved by the Human Ethics Committee Curtin University of Technology (Approval No. PT231/2013) and University Putra Malaysia Ethics Committee (Ref. No: IG_April Curtin (13) 04).

Consent Form.Ver.2.0/May 2013 Page 2/2

Appendix 5: (continued) Consent Form

IDRESPONDEN : RESPONDEN ID : ☐☐☐☐☐

Curtin University

PENILAIAN RISIKO JATUH DAN KEBERKESANAN SENAMAN DI RUMAH KE ATAS KESEIMBANGAN DAN

FALLS RISK ASSESSMENT AND EFFECTIVENESS OF HOME BASED EXERCISE ON BALANCE AND FUNCTIONAL MOBILITY AMONG OLDER MALAYSIAN AGED 50 YEARS AND ABOVE

UPM UNIVERSITI PUTRA MALAYSIA

1. Nama Responden ¤ *Respondent's Name* : ____________________
2. IC Responden ¤ *IC Responden* : ____________________
3. Kod Responden ¤ *Respondent Code* :
   - ☐ 0 1 2 3 4 5 6 7 8 9
   - ☐ 0 1 2 3 4 5 6 7 8 9
   - ☐ 0 1 2 3 4 5 6 7 8 9
4. Alamat Sekarang ¤ *Current Address* : ____________________
   : ____________________ *Postcode :* ________
5. Nombor Hubungi ¤ *Contact No* : *Mobile No :* ________ *Home :* ________
   : *e-mail Address:* ____________________

kriteria saringan ¤ *screening criteria*

6. Adakah responden ¤ *does respondent* :

	Ya ¤ *Yes*	Tidak ¤ *No*	
a) Berumur 50 tahun dan ke atas ¤ *Aged 50 and above*	1	0	a
b) Tinggal di komuniti ¤ *Community dwelling*	1	0	b
c) Abnormal limit of turning mild balan☐e problem ¤ *cognitively intact*	1	0	c
d) Boleh berjalan dan berdiri tanpa sokongan/ alat bantuan sekurang-kurangnya 6 minit ¤ *able to walk and stand without aid at lest within 6 minutes*	1	0	d

Semakan ¤ *Checking*

7. Tarikh disemak ¤ *Date of checking*
   - **Hari** ☐ 0 1 2 3 4 5 6 7 8 9 / ☐ 0 1 2 3 4 5 6 7 8 9
   - **Bulan** ☐ 0 1 2 3 4 5 6 7 8 9 / ☐ 0 1 2 3 4 5 6 7 8 9
   - **Tahun** ☐ 0 1 2 3 4 5 6 7 8 9 / ☐ 0 1 2 3 4 5 6 7 8 9
8. Status Semakan Borang ¤ *Status Form Checking*

   1 : Lulus ¤ *Approved* 2 : Perlu pindaan ¤ *Amendment necessary* 3 : Ditolak ¤ *Rejected*

Appendix 6: Cover page QuestionnaireBooklet

Curtin University

Memorandum

To	Asmidawati Ashari
From	Associate Professor Helen Slater
Subject	Protocol Approval PT231/2013
Date	31 May, 2013
Copy	Professor Keith Hill

Office of Research and Development
Human Research Ethics Committee
Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled *"Fall risk assessment and effectiveness of home based exercise on balance and functional mobility among older Malaysia aged 50 years and above"* On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of four years from **30 May 2013** to **30 May 2017.**

The approval number for your project is **PT231/2013.** *Please quote this number in any future correspondence.* If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

Associate Professor Helen Slater
Coordinator, Ethics Committee

(Please contact (08) 9266 3618 or email H.Slater@curtin.edu.au if you wish to discuss the School of Physiotherapy fasttrack process of your application or any specific enquiries regarding your application.)

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved under Curtin University's process for lower-risk Studies (Approval Number PT). This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21).
For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 9266 9223 or by emailing hrec@curtin.edu.au

J:/Physiotherapy/Research &Development/Ethics/Human Ethics/Templates/ApprovalForm C 2012.doc
CRICOS Provider Code 00301J

Appendix 7: Curtin Human Ethic Approval Letter

La Trobe University
Faculty of Health Sciences
MEMORANDUM

TO:	Professor Keith Hill Zaiton Ahmad Mohd Tizal Hussain Mohd Fadzillah Bagat	School of Physiotherapy
SUBJECT:	*Reference:*	**FHEC11/099**
	Student's Name &/or Other Investigator(s):	**Asmidawati Ashari**
	Title:	**Fall prevalence and risk assessment among community dwelling older adults (aged 50 years and above) in Malaysia**
DATE:	17 August, 2011	

Appendix 8: Letter of Ethic Approval Ethic Committee La Trobe University, (EC00262), FHEC11/099, La Trobe University, Bundoora, Victoria, Australia

FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES

MS ISO 9001 : 2000 Reg. No. AR 4268

Reff : UPM/FPSK/PADS/T7-MJKEtikaPer/F01(IG_NOV(10)01)
Date : 27 July 2011

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RESEARCH PROJECT:

ASSESSMENT OF POSTURAL BALANCE AND RISK OF FALLING AMONG OLDER LEARNERS AT THE UNIVERSITY OF THE THIRD AGE (U3A), MALAYSIA

RESEARCHER : MOHD RIZAL HUSSAIN

The Medical Research Ethic Committee of the Faculty of Medicine and Health Sciences has studied the proposal for the above project and find that there are no objectionable ethical issues involved in the proposed study.

Notwithstanding above, the Faculty will not be responsible for any misconduct on the part of researcher in the course of carrying out the research.

Thank you.

"WITH KNOWLEDGE WE SERVE"

Sincerely yours,

PROFESOR DR. NORLIJAH OTHMAN
Chairman
Medical Research Ethic Committee
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia

c.c : Fail Induk – Etika

Appendix 9: Letter of Ethic Approval, Research Ethics Committee of Universiti Putra Malaysia, Malaysia (Study 1).

UNIT PERANCANG EKONOMI
Economic Planning Unit
JABATAN PERDANA MENTERI
Prime Minister's Department
BLOK B5 & B6
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62502 PUTRAJAYA
MALAYSIA

EPU

Telefon : 603-8872 3333

Ruj. Tuan: Your Ref.: UPE: 40/200/2792

Ruj. Kami: Our Ref.:

Tarikh: Date: 14 April 2011

Asmidawati Ashari
No.6 Jalan Bpp 7/2 ,
The Eminence Park,
Bandar Putra Permai,
43300 Seri Kembangan Selangor
Email: asmidawati@gmail.com

APPLICATION TO CONDUCT RESEARCH IN MALAYSIA

With reference to your application dated **10 August 2009**, I am pleased to inform you that your application to conduct research in Malaysia has been *approved* by the **Research Promotion and Co-Ordination Committee, Economic Planning Unit, Prime Minister's Department.** The details of the approval are as follows:

Researcher's name :	**ASMIDAWATI BINTI ASHARI**
Passport No. / I. C No:	**780124-03-6102**
Nationality :	**MALAYSIAN**
Title of Research :	**"FALL PREVALENCES AND RISK ASSESSMENT AMONG COMMUNITY DWELLING OLDER ADULTS (AGED 50 YEARS AND ABOVE) IN MALAYSIA"**

Period of Research Approved: **3 MONTHS**

2. Please collect your Research Pass in person from the **Economic Planning Unit, Prime Minister's Department, Parcel B, Level 4 Block B5, Federal Government Administrative Centre, 62502 Putrajaya** and bring along two (2) passport size photographs. You are also required to comply with the rules and regulations stipulated from time to time by the agencies with which you have dealings in the conduct of your research.

Appendix 10: Letter of approval to conduct research in Malaysia from Economic Planning Unit (EPU), Department of the Prime Minister of Malaysia (Study 1).

RESEARCH MANAGEMENT CENTRE (RMC)
DEPUTY VICE CHANCELLOR OFFICE (RESEARCH AND INNOVATION)
Tel: 03-89471244 Fax: 03-89451596

MEMORANDUM OF COMMUNICATION

Date	:	**21 Mei 2013**
To	:	**Asmidawati Ashari /Professor Keith Hill**
Subject	:	**Ethical Clearance Approval (Ref. No: IG_April Curtin (13) 04)**

Dear Asmidawati,

Kindly refer to the above matter.

Please be informed that application of ethic clearance for the research entitled **'Fall Risk Assessment And Effectiveness Homed Based Of Exercise On Balance And Functional Mobility Among Older Malaysian Adults Aged 50 Years And Above' (Ref. No: IG_April Curtin (13) 04)** has been approved by JKEUPM meeting which held on May 10, 2013. Accordingly, the approval letter will be issued in the near future.

Thank you

"With Knowledge We Serve"

Sincerely,

SUZITA RAMLI
JKEUPM Secretariat
Universiti Putra Malaysia
43400 UPM, Selangor
Malaysia.

SUZITA RAMLI
Pegawai Sains
Pusat Pengurusan Penyelidikan (RMC)
Pejabat Timbalan Naib Canselor
(Penyelidikan & Inovasi)
Universiti Putra Malaysia
43400 UPM Serdang, Selangor.

Appendix 11: Letter of Ethic Approval, Research Ethics Committee of Universiti Putra Malaysia, Malaysia (Study 2).

UNIT PERANCANG EKONOMI
Economic Planning Unit
JABATAN PERDANA MENTERI
Prime Minister's Department
BLOK B5 & B6
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62502 PUTRAJAYA
MALAYSIA

EPU

Telefon : 603-8872 3333

Ruj. Tuan:
Your Ref.:

Ruj. Kami: UPE: 40/200/2792
Our Ref.:

Tarikh: 13 March 2013
Date:

Asmidawati Ashari
No.6 Jalan Bpp 7/2 ,
The Eminence Park,
Bandar Putra Permai,
43300 Seri Kembangan Selangor
Email: asmidawati@gmail.com

APPLICATION TO CONDUCT RESEARCH IN MALAYSIA

With reference to your application, I am pleased to inform you that your application to conduct research in Malaysia has been *approved* by the **Research Promotion and Co-Ordination Committee, Economic Planning Unit, Prime Minister's Department.** The details of the approval are as follows:

Researcher's name :	**ASMIDAWATI BINTI ASHARI**
Passport No. / I. C No:	**780124-03-6102**
Nationality :	**MALAYSIAN**
Title of Research :	**"FALL RISK ASSESSMENT AND EFFECTIVENESS OF HOME BASED EXERCISE ON BALANCE AND FUNCTIONAL MOBILITY AMONG OLDER MALAYSIA AGED 50 YEARS AND ABOVE"**

Period of Research Approved: **3 MONTHS**

2. Please collect your Research Pass in person from the **Economic Planning Unit, Prime Minister's Department, Parcel B, Level 4 Block B5, Federal Government Administrative Centre, 62502 Putrajaya** and bring along two (2) passport size photographs. You are also required to comply with the rules and regulations stipulated from time to time by the agencies with which you have dealings in the conduct of your research.

Appendix 12: Letter of approval to conduct research in Malaysia from Economic Planning Unit (EPU), Department of the Prime Minister of Malaysia (Study 2).

Appendix 11 : Correlation matrix (Pearson r) between clinical and laboratory measures of balance.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Timed Up and Go (sec)	1														
2	Timed Up and Go with Dual Task (sec)	.767**	1													
3	Functional reach Test	-.256**	-.214**	1												
4	Step Test (worse steps)	-.535**	-.503**	.365**	1											
5	Five Timed Chair Stands (sec)	.336**	.383**	-.099	-.169*	1										
6	mCTSIB Composite score mean COG sway (deg/sec)	.129	.174*	-.051	-.150	-.031	1									
7	LOS Composite reaction time (sec)	.173*	.085	-.070	-.333**	.002	.016	1								
8	LOS Composite Movement Velocity (deg/sec)	-.266**	-.255**	.141	.307**	-.111	-.125	-.529**	1							
9	LOS Composite Maximum excursion (%)	-.199*	-.184*	.154	.264**	-.069	-.294**	-.420**	.540**	1						
10	LOS Composite Endpoint excursion (%)	-.234**	-.249**	.078	.232**	-.104	-.340**	-.347**	.520**	.853**	1					
11	LOS Composite Directional Control (%)	-.136	-.092	.100	.178*	-.091	-.195*	-.095	.023	.604**	.481**	1				
12	Walk across - Step width (cm)	.088	.247**	.047	-.135	.050	.084	-.006	.013	.013	-.013	.056	1			
13	Walk across -Step Length (cm)	-.524**	-.490**	.207**	.459**	-.219**	-.158*	-.144	.281**	.304**	.284**	.319**	-.051	1		
14	SQT, worst sway turning (deg/sec)	.269**	.343**	-.187*	-.301**	.178*	.077	.110	-.151	-.132	-.122	-.069	.123	-.387**	1	
15	SQT, worst time turning (sec)	.380**	.356**	-.202*	-.364**	.122	.145	.166*	-.212**	-.107	-.080	-.014	.033	-.427**	.606**	1

**. Correlation is significant at the 0.01 level (2-tailed).

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

Appendix 13: A correlation matrix of all balance and mobility measures

Authors:

Asmidawati Ashari, BSc
Tengku Aizan Hamid, PhD
Mohd Rizal Hussain, BSc
Keith David Hill, PhD

Affiliations:

From the School of Physiotherapy and Exercise Science, Curtin University, Perth, Western Australia, Australia (AA, KDH); and Institute of Gerontology, Universiti Putra Malaysia, Selangor, Malaysia (AA, TAH, MRH).

Correspondence:

All correspondence and requests for reprints should be addressed to: Asmidawati Ashari, BSc, School of Physiotherapy and Exercise Science, Faculty of Health Sciences, Curtin University, Perth, Western Australia 6845, Australia.

Disclosures:

Supported by the Universiti Putra Malaysia Grant (UPM7/00-211GP-IPM2013/9404500).
Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

0894-9115/15/0000-0000
American Journal of Physical Medicine & Rehabilitation

DOI: 10.1097/PHM0000000000000388

ORIGINAL RESEARCH ARTICLE

Effectiveness of Individualized Home-Based Exercise on Turning and Balance Performance Among Adults Older than 50 yrs

A Randomized Controlled Trial

ABSTRACT

Ashari A, Hamid TA, Hussain MR, Hill KD: Effectiveness of individualized home-based exercise on turning and balance performance among adults older than 50 yrs: a randomized controlled trial. Am J Phys Med Rehabil 2015;00:00–00.

Objective: This study evaluated the effectiveness of an individualized home-based exercise program that included specific turning exercises in improving turning performance in adults identified as having unsteadiness during turning.

Design: A single-blind (assessors) randomized controlled trial was conducted with 68 community-dwelling Malaysians aged 50 yrs and older, who had abnormal turning performance (outside of age and sex, normal limits on the Step/Quick Turn Test [180-degree turn task on the NeuroCom Balance Master with long plate]). The intervention group received a 16-wk home exercise program that included two turning exercises, whereas the control group maintained their usual activities.

Results: Significant group × time effects were found using two-way repeated-measures analysis of variance for turning and balance/mobility measures. The intervention group significantly improved relative to the control group for (1) sway when turning 180 degrees Step/Quick Turn, $F_{1,65} = 8.070$, $P = 0.006$; (2) time to perform 180-degree turn Step/Quick Turn, $F_{1,65} = 8.216$, $P = 0.006$; (3) Timed Up and Go (single task), $F_{1,65} = 6.647$, $P = 0.012$; (4) Timed Up and Go (dual task), $F_{1,65} = 8.301$, $P = 0.005$; and (5) static stance sway, $F_{1,65} = 10.491$, $P = 0.002$.

Conclusions: An individualized home exercise program that included specific exercises to improve turning ability was effective in improving turning performance in adults older than 50 yrs.

Key Words: Exercise, Postural Balance, Adults

Appendix 14 : Copy of paper publish (Ashari et al, 2015)