An Examination of the Relationship between Gait, Cognition and Risk of Falling in an Older Population Based Sample

by

Kara L. Martin, BSc (Mathematics) (Hons)

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

Menzies Research Institute
University of Tasmania
July 2011
Declaration of originality

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by any other person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.

Signed: ………………………………………. Date: ……………………………..
Statement of authority of access

This thesis can be made available for loan. Copying of any part of this thesis is prohibited for two years from the date this statement was signed; after that time limited copying is permitted in accordance with the Copyright Act 1968.

Signed: .................................................. Date: .................................
Statement of authorship

This thesis includes papers for which Kara Martin (KM) was not the sole author. KM was the lead in this research as she participated in data collection, analysed the data and wrote the manuscripts. However, she was assisted by the co-authors whose contributions are detailed below.

1. The paper reported in Chapter 4:


The contribution of each author:
KM participated in data collection, data management and cleaning, and comprised the initial draft of the manuscript. With LB, she undertook all the analyses and interpretation of the data, and completed revisions.
AW helped with analyses and interpretation of the results and revised the manuscript.
LB with KM undertook all the analyses and interpretation of the data and revised the manuscript.
RT helped with analyses and interpretation of the results and revised the manuscript.
MC helped with analyses and interpretation of the results and revised the manuscript.
LS helped with analyses and interpretation of the results and revised the manuscript.
VS was responsible for obtaining approvals, design and conduct of the study and helped with interpretation of the results and revised the manuscript.
2. The paper reported in Chapter 5:

Martin K, Blizzard L, Garry M, Thomson R, McGinley J, Srikanth V, Gait initiation in older people – time to first lateral movement may be the measure of choice, Gait and Posture, 2011, Article in press.

The contribution of each author:
KM participated in data collection, data management and cleaning, and comprised the initial draft of the manuscript. With LB, she undertook all the analyses and interpretation of the data, and completed revisions.
LB with KM undertook all the analyses and interpretation of the data and revised the manuscript.
MG helped with analyses and interpretation of the results and revised the manuscript.
RT helped with analyses and interpretation of the results and revised the manuscript.
JM helped with analyses and interpretation of the results and revised the manuscript.
VS was responsible for obtaining approvals, design and conduct of the study and helped with interpretation of the results and revised the manuscript.

3. The paper reported in Chapter 6:


The contribution of each author:
KM participated in data collection, data management and cleaning, and comprised the initial draft of the manuscript. With RT and LB, she undertook all the analyses and interpretation of the data, and completed revisions.
RT with KM undertook all the analyses and interpretation of the results and revised the manuscript.
LB with KM undertook all the analyses and interpretation of the data and revised the manuscript.
AW helped with analyses and interpretation of the results and revised the manuscript.
MG helped with analyses and interpretation of the results and revised the manuscript.
VS was responsible for obtaining approvals, design and conduct of the study and helped with interpretation of the results and revised the manuscript.

4. The paper reported in Chapter 7:


The contribution of each author:
KM participated in data collection, data management and cleaning, and comprised the initial draft of the manuscript. With LB, she undertook all the analyses and interpretation of the data, and completed revisions.
LB with KM undertook all the analyses and interpretation of the data and revised the manuscript.
RT helped with analyses and interpretation of the results and revised the manuscript.
MC helped with analyses and interpretation of the results and revised the manuscript.
LS helped with analyses and interpretation of the results and revised the manuscript.
VS was responsible for obtaining approvals, design and conduct of the study and helped with interpretation of the results and revised the manuscript.

Signed by first named supervisor, A/Prof Leigh Blizzard:

Signed: ……………………………………….. Date: ……………………………
Abstract

Falls are a significant public health problem for older people. Their prevention is important to reduce hospital admissions, and related loss of independence, morbidity and mortality. They have multiple risk factors, including impaired cognitive function and gait deterioration. Inter-relationships between cognitive function and gait in contributing to falls are poorly understood, with few data from population-based studies.

This thesis aimed to examine the associations between cognitive function, gait and the risk of falling in a series of studies conducted in a population-based sample of older people aged 60-86 years.

Cognitive functions were assessed from a battery of tests. Gait was assessed using the GaitRite walkway and a force platform. Falls-risk was assessed using the Physiological Profile Assessment, and falls were recorded prospectively using a 12-month diary.

In the first study, measurements of GI using the GaitRite walkway were compared with those on the same 28 subjects measured using a 200Hz force platform, considered to be the gold standard. The GaitRite walkway measurements had higher systematic error and inferior predictive validity for falls-risk.

In the second study, poorer processing speed and executive function/attention, but not deficits in memory or visuospatial ability, were independently associated with poorer gait. Deficits of processing speed, executive function and visuospatial ability were associated with increased intra-individual gait variability in double support phase, a measure of balance during gait.

In the third study, time to first lateral movement could be the best measure of gait initiation, given its consistent associations with surrogates of falls-risk and cognition, while also being most responsive to cognitive interference from dual-tasking.

In the fourth study, executive function, processing speed and visuospatial ability, but not memory, were independently associated with a surrogate measure of falls-risk.
In the final study, poorer executive and visuospatial functions predicted the risk of multiple falls. The associations between all cognitive functions and the risk of multiple falls were magnified in those with poorer sensorimotor function, gait speed or ambulatory activity.

These studies add significantly to knowledge about the relationships between cognitive functions, gait and the risk of falling, in community-dwelling older people. Consistent with prior studies, executive function and processing speed may either be involved in gait control or share the same neural substrate. Visuospatial ability, a higher cortical function reflecting sense of space and position, was associated with gait. Memory appeared to have the least influence. Cognitive function and physical sensorimotor impairments were found to interact in predicting multiple falls, suggesting that brain reserve capacity plays a role in compensating for physical frailty in older people. Lastly, these data substantially add to the issue of the choice of measure of gait initiation, and will guide future studies in this field.
Acknowledgements

First and foremost, I would like to thank my supervisor and chief investigator on the Tasmanian Study of Cognition and Gait (TASCOG), Dr Velandai Srikanth. Thank you for taking a chance on me and teaching me the world of epidemiology. I have thoroughly enjoyed working on TASCOG. Thank you also for the financial support that allowed me to complete this work.

Thank you to my primary supervisor, Associate Professor Leigh Blizzard. Without your help I would never have started at the Menzies Research Institute. Thanks for your patience and support and your never ending passion for good statistics. I have learnt a lot about biostatistics in the last four years.

Thank you to my co-supervisors Dr Russell Thomson, Dr Mike Garry and Dr Amanda Wood, for helping me whenever I asked. Russ thanks for the stats advice, the coffees and chats about music. Thanks to Mike and Amanda for your encouragement and always taking the time to answer my “silly questions”.

Thank you to everyone involved in TASCOG – Shalee Richardson, Clare Munro and Kate Butorac as well as all the staff and volunteers. Thanks also to Tim Albion, Alistair Chilcott and Ben Duan for the big paperclip. Also thanks to the participants who kindly donated their time to participate in the TASCOG study.

Thank you to the great environment of Menzies Research Institute. I’ve really enjoyed working with such a close-knit bunch of people. Thanks also to the University of Tasmania, the Emerging Researchers in Ageing group and the Victoria League for Commonwealth Friendship (Hobart) Medical Research Trust for their financial assistance.

There are a few people in particular that I would like to mention. I would like to give a massive thanks to my partner in crime Michele Callisaya. Thanks for always answering my dumb questions and keeping me sane. Working with you on TASCOG has been tremendous. Here’s to weeping willows!
I would also like to thank my fellow students and Menzies staff notably Kylie, Petr, Peta, Ollie, Bek, Dawn, Fiona, Stella, Dave, Laura, Charlotte, Jana and Steve. Thanks for your support, encouragement and chats.

Thank you to my wonderful friends who have supported me through my PhD and to the swing dancers who always have a smile on their face. In particular, thank you Bryce, Relle, Cath, Helen, Tim, Siobhan, Bunch, Nat and Stu, Rhea, Troy and Michael. Thank you also to Spoon. I may never have had an interest in maths and statistics if it were not for you.

Thank you to Mum and Dad for your never-ending support and love and the belief that I could and would get through this. Last but not least, I would like to thank my partner Kim (and Cino and Tigger) for being my rock of support and for cooking me dinner.
# Table of contents

Declaration of originality ........................................................................................................i
Statement of authority of access ..............................................................................................ii
Statement of authorship ..........................................................................................................iii
Abstract .....................................................................................................................................vi
Acknowledgements .............................................................................................................viii
Table of contents .................................................................................................................. xi
List of tables ......................................................................................................................... xv
List of figures ........................................................................................................................ xvi
List of abbreviations .............................................................................................................. xvii
Publications ........................................................................................................................... xviii
  Publications directly arising from the work described in this thesis ................ ............ xviii
  Manuscripts submitted for peer-reviewed journals ......................................................... xviii
  Other publications ............................................................................................................. xviii
Conference presentations using the work described in this thesis ................................... xix
Awards received from the work described in this thesis .................................................... xix
Chapter 1: Introduction .......................................................................................................... 1
  1.1 Background .................................................................................................................. 1
  1.2 Falls in older people ..................................................................................................... 1
    Measurement of falls ......................................................................................................... 2
    Incidence of falls in older people .................................................................................... 2
    Consequences of falls ................................................................................................. 3
  1.3 Established risk factors for falls .................................................................................. 3
  1.4 Cognitive function as a risk factor for falls ................................................................. 5
    Fundamental cognitive functions .................................................................................. 6
    Instrumental cognitive functions .................................................................................. 8
  1.5 Gait as a risk factor for falls ........................................................................................ 10
    Definitions of gait, gait variability and gait initiation .................................................. 10
    Gait and gait variability ............................................................................................... 10
    Gait initiation ............................................................................................................... 12
  1.6 Brain function and gait ............................................................................................... 14
  1.7 Cognitive function and gait ........................................................................................ 15
7.6 Conclusions............................................................................................................. 139
7.7 Postscript............................................................................................................. 140
7.8 References............................................................................................................. 140
Chapter 8: Summary .................................................................................................. 146
  8.1 Background and aims of the thesis ................................................................. 146
  8.2 Methods ............................................................................................................. 147
  8.3 Major findings and implications ..................................................................... 148
      Can we use the GaitRite walkway to accurately measure gait initiation?
      (Chapter 3) ........................................................................................................... 148
      Cognitive function, gait and gait variability in older people – a population-based
      study. (Chapter 4) ............................................................................................... 149
      Gait initiation in older people – time to first lateral movement may be the
      measure of choice. (Chapter 5) ........................................................................... 150
      Visuospatial ability and memory are associated with falls-risk in older people –
      a population-based study. (Chapter 6) .............................................................. 151
      Poorer cognitive function modifies the effect of poorer physiological function
      on multiple falls. (Chapter 7) .............................................................................. 151
  8.4 Clinical implications .......................................................................................... 152
  8.5 Recommendations for future research ........................................................... 153
  8.6 Conclusions......................................................................................................... 154
  8.7 References........................................................................................................... 155
Bibliography ............................................................................................................... 156