

In the name of omniscient, omnipotent, omnipresent

**Foot characteristics and its association with balance in
older adults**

A thesis submitted in fulfillment of the
requirements for the award of the degree

Doctor of Philosophy

from

University of Tsukuba

by

Mahshid Saghazadeh

**Graduate School of Comprehensive Human Sciences, Faculty of Health
and Sport Sciences**

March 2015

Dedication

I would like to dedicate this thesis to my parents. Their encouragements, unconditional love and pray of day and night has got me where I am today.

Abstract

Population aging is widespread across the world and it is more in the most highly developed countries such as Japan. With aging, balance ability is widely acknowledged to decline. Maintenance of balance depends on the interaction of multiple sensory motor and integrative systems. Function of these systems declines with age and can lead to fall. Such fall incidents require medical attention and making individuals grapple with pain and suffering as well as placing a financial burden on patients, their family and society. All these reasons indicate that we are in dire need of protective measures in all social, economic, cultural aspects and also health care.

Most falls occur while an individual is in motion. During normal gait, the foot is the only source of direct contact with the ground. Therefore, the foot plays a considerable role in maintaining balance and stability during movement. Despite this, little is known about foot characteristics and its association with balance in older adults. Therefore, the primary aim of this thesis was to determine whether foot characteristics, which were foot deformity and static foot posture, associate with balance in independently-living older adults. As the foot and toes play crucial role in safe and efficient movement, it was hypothesised that foot deformity would be associated with poor balance. Furthermore, the association between balance and static foot posture, which in this study was arch height calculated using two different ways of measurements, was investigated. The secondary aim was identify gender differences in foot characteristics to design comfortable and efficient shoes

in Japan which has large elderly population.

A total of 349 older adults participated in this study conducted in the Kasama City health center. Of these participants, we excluded some due to incomplete data, their reliance on walking sticks during the measurement or among women because of refusing to remove their pantyhose preventing us from collecting foot characteristic and balance or postural sway data. We assessed foot characteristics, using the recently launched 3D foot scanner by Dream GP Company, Japan. Balance tests and body mass index (BMI) of participants were measured and medical histories were gathered via face-to-face interviews.

There is significant positive correlation between the first toe angle and poor balance especially in women. Therefore, the first toe angle is an important determinant of balance in community-dwelling older people.

Furthermore, our study provides intriguing findings on the associations between sitting arch height index (AHI) and balance in both genders. Arch rigidity index (ARI) is associated with postural sway and static balance in women and men, respectively. Moreover, sitting navicular height (NH) and foot mobility are associated with postural sway in women and with balance in men. These findings suggested that among all those methods, sitting AHI might be better method for defining balance control in older adults.

In addition, the current study shows evidence of difference between some of the foot characteristics and shapes of older men and women. Gender differences in older adult's foot shape should be considered when manufacturing shoes for them.

Table of Contents

I.	Introduction	1
1.	Background of the study.....	1
2.	Necessity of the study.....	3
3.	Aim of the study.....	5
4.	Definition of terms	5
II.	Literature reviews	8
1.	Foot deformity & physical performance	8
2.	Static foot posture & balance	11
3.	Gender difference in foot characteristics.....	13
III.	Research agenda	17
1.	Procedure.....	17
2.	Limitations of this study	18
IV.	Research theme 1: Foot deformity & physical performance.....	20
1.	Introduction.....	20
3.	Results	28
4.	Discussion.....	30
5.	Conclusion	31
V.	Research theme 2: Static foot posture & balance	33
1.	Introduction.....	33
2.	Methods	36
a.	Navicular height (NH) & navicular drop (ND)	39
b.	Arch height index (AHI) & arch rigidity index (ARI)	41

3.	Results	44
a.	Results of NH & ND.....	44
b.	Results of AHI & ARI.....	51
4.	Discussion.....	60
5.	Conclusion	63
VI.	Research theme 3: Gender difference in foot characteristics	64
1.	Introduction.....	64
2.	Methods	66
a.	Navicular height (NH) & navicular drop (ND)	69
b.	Arch height index (AHI) & arch rigidity index (ARI).....	70
3.	Results	72
4.	Discussion.....	74
5.	Conclusion	76
VII.	General discussion	80
VIII.	Conclusion.....	85
	Acknowledgement.....	87
	References	89
	Publications	101