

# Foot Anthropometric Measurements of Hong Kong Elderly: Implications for Footwear Design<sup>★</sup>

Pui-Ling Li<sup>a</sup>, Kit-Lun Yick<sup>a,\*</sup>, Sun-Pui Ng<sup>b</sup>, Joanne Yip<sup>a</sup>

<sup>a</sup>*Institute of Textiles and Clothing, The Hong Kong Polytechnic University, HungHom, Hong Kong*

<sup>b</sup>*Hong Kong Community College, The Hong Kong Polytechnic University, HungHom, Hong Kong*

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## Abstract

Degenerative changes and foot deformities are common when people get older. Foot deformities, such as hallux valgus, bunionettes and pes planus, are commonly found among older people, which may lead to changes in foot anthropometry. A decline in functional mobility and greater risk of falling are linked to foot deformities and footwear. This study therefore aims to evaluate the anthropometric measurements between healthy and deformed feet in order to determine the key foot measurements in relation to the deformed foot which can also act as indicators in current footwear sizing systems. By using a 3D hand-held scanner, 11 foot anthropometric measurements are captured and used to characterise the dimensions and foot shape between healthy and deformed feet. A total of 49 elderly people between the ages of 65-95 years old, including 41 women and 8 men (mean: 81.71; SD: 7.08) are recruited for this study. The results indicate that the foot characteristics of elderly people with foot deformities are different from those without deformities, especially in the larger deformity of the degree of hallux valgus and increased width of the ball for women, and higher instep height for men. The length of the foot and ball, width and girth of the ball, and degree of hallux valgus deformity are common predictors for differentiating between healthy and deformed feet. It is also found that the current footwear sizing systems fail to accommodate the foot dimensions of elderly people in both foot length and width, which may therefore lead to foot discomfort and even limit their daily life activities.

*Keywords:* Foot problems; Anthropometry; Footwear design; Elderly; 3D scanning

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## 1 Introduction

Ageing appears to be a major concern of the 21st century in almost every country. According to the World Health Organisation, one in every nine people in the world is 60 years old or older. This is expected to increase to one in every five people by 2050 [1]. Due to physical, sensory, and cognitive changes, falling and instability in balance are one of the well-recognised problems of older people. Apart from age-related loss of foot sensation that impairs the control of balancing reactions, the wearing of poorly fitted footwear has been identified as a major environmental risk

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\*Corresponding author.

*Email address:* kit-lun.yick@polyu.edu.hk (Kit-Lun Yick).

factor for increasing the risk of falls [2]. On the other hand, foot morphology gradually changes with age and health conditions. Such changes may cause increased weight-bearing forces and excessively high pressures throughout the lower kinetic chain [3, 4]. According to a local study, about 50% of the studied geriatric patients were found to have various types of foot deformities, including pes planus, pes cavus, hallux valgus, bunionettes and enlargement of the width and height of the feet due to toe deformities or thickened nails [5]. A recent local study revealed that about 80% of the studied elderly people have at least one foot problem and/or various types of foot deformities [6]. Deformed feet may lead to a decline in functional mobility and add to a greater risk of falling. As compared to younger people, older people tend to have flatter, longer and wider (larger circumference) feet [7]. It is difficult for the elderly to find well-fitting shoes in the market since most shoe manufacturers utilise data from the feet of young adults for their shoe designs [8]. In traditional footwear sizing systems, customers are required to take the measurement of their foot length with a measuring tape or use the Brannock device to select a suitable size for footwear. However, the feet of older people are generally broader than the shoes available in their size. Reports have indicated that around 80% of older people wear shoes that are too narrow and too short for their feet, which lead to lesser toe and hallux valgus deformities, corns on the toes and foot pain [9, 10]. Despite the fact that footwear can provide support for the lower extremity muscles and foot protection from injuries, many older people may prefer walking barefoot or in socks for comfort at the risk of a ten-fold increase in falling [11, 12].

In consideration of the footwear sizing and fitting problems, it is anticipated that foot shape and anthropometry can facilitate footwear manufacturers to design appropriate shoes for older people. As indicated by Tomassonic et al [13], knowledge of the metatarsophalangeal joint location can help select the most suitable footwear fabrication materials for cushioning and shock absorption to improve comfort during foot-strike. Additionally, measurements of ball width, ball girth and degree of hallux valgus can also provide useful reference in toe box design and shoe volume. In light of the increasing population of older people and their increasing demands for footwear, foot anthropometry related studies have been conducted in Brazil, Australia, Thailand, Japan, etc [3, 10, 14, 15]. As ethnic origin and the corresponding life style can influence foot shape, a study on the foot characteristics of older adults in each nation is infeasible. To the best of our knowledge, no previous investigations have been made on measuring the foot morphology of older people in Hong Kong in relation to their deformed foot. The aim of this study is to therefore characterise the dimensions and foot shape of the elderly in Hong Kong and compare the anthropometric measurements of healthy and deformed feet. The key foot measurements that determine the deformed foot in the elderly will also be determined. Since poorly fitting footwear is a known risk factor of falls for older people, their foot shape characteristics will also be compared with the current footwear sizing systems. The findings of this study are important for improving current understanding on anthropometric measurements of the deformed foot and providing more information that will improve the fit and comfort of footwear for older people.

## **2 Method**

### **2.1 Participants**

A total of 49 elderly people between 65-95 years old, including 41 women and 8 men (mean: 81.71; SD: 7.08) were recruited from a local self-care residence for this study. The inclusion criteria are