

Common foot deformities among Malaysian women: wearing incorrectly sized shoes

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Abstract - Several foot deformities have been identified in Malaysian women due to wearing shoes which do not fit the size and shape of their feet. Hallux valgus (bunions), corn, cellulites and ingrown toenail are among the common deformities experienced by Malaysian women. The root of this issue is that the Malaysian footwear market has adopted foreign shoe size standards such as those from the US and UK. This means that Malaysian women face difficulties in obtaining correctly-sized shoes. Therefore, the aim of this study is to develop and propose a standard shoe sizing system for women in Malaysia based on anthropometric measurements of Malaysian women's foot sizes and shapes. Women from Malaysia's primary ethnic groups (Malay, Chinese, and Indian) aged 20 to 60 years old participated in this project, where the anthropometric measurements for their foot size and shapes were obtained using a 3D foot scanner. Regression analysis in the form of Generalized Linear Model (GLM) was performed to determine the association between a few attributes including foot measurements and the existence of the foot deformities. Foot length and Ball girth circumference have significant association with the foot deformities (FL: $p = .028$ and BG: $p = .045$). The new standard shoe sizing system has been developed with more accurate sizes and shapes, it is hoped that the foot deformities problem could be solved or at least reduced the foot pain.

Keywords: Malaysian women; shoe size; foot measurement; foot deformities

I. INTRODUCTION

Footwear is designed to protect human feet from danger and to provide comfort, especially when outdoors [1,2,3]. Footwear is used for everyday standing and walking [4] and must be correctly sized, since improper fitting may result in foot problems. A customer may lose confidence in a product if she needs to select a size different from what he or she should wear during a purchase. It is a fact that different individuals have their own personal standards of what is an acceptable fit. Some look for a very tight, snug fit, while others look for a looser one. As a result, 85% of the world population has been found to be wearing incorrectly-sized shoes [5] and 86% are wearing shoes that were narrower than their feet [6].

Ill-fitting shoes are the cause of several foot pain and foot disorders such as lesser toe deformity, corns, calluses and ingrown toe nails. Studies by [7,8] mentioned that wearing tight or short shoes without allowing enough space at the toes for air to move was the highest predisposing factor causing toenails fungus. Based on samples surveys of adults in different countries, several studies reported that an estimate of

21% – 65% of the general population experienced the prevalence of hallux valgus and the occurrence are more prominent among women than men [9,10].

Currently, Malaysia does not have its own set of standard shoe sizes suitable for Malaysians' foot sizes. The Malaysian footwear market has adopted foreign size standards such as those from the US and UK [11]. These foreign standards are not suitable for Asian population due to the differences in foot size and shape when compared to Westerners. Research has found that about 80% to 90% of Malaysian adults suffer from some foot problems and one of the reasons is due to uncorrected shoe size [12]. In this study, an initial pilot survey was conducted in order to study the feeling of Malaysian women towards the shoes they are wearing. The results obtained showed that 60.3% of Malaysian women felt that they do not have enough choices in choosing a suitable shoe size, while 66.3% reported facing difficulties in obtaining the right size for their feet. Hence, 68.3 % Malaysian women will eventually lose interest in purchasing shoes and end up 46% owning only a single pair of shoes. Such difficulties have led Malaysian women to opt for sandals for daily activities,

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as comfort is one of the primary factors in choosing shoes. Out of 309 participants in the pilot survey, 23 of them have hallux valgus deformity as result of wearing the wrong shoes sizes. A common problem among who have hallux valgus is one or more abnormalities in their gait pattern due to deformation of the first metatarsophalangeal joint [13]. Currently, the measurements of shoe sizes for off-the-racks shoes are not suitable for Malaysian women. They require shoe sizes that really fit the measurement of their feet. It is highly agreeable that the issue of shoe sizing and fit is serious in Malaysia. Ill-fitting shoes might lead to problems and deformities of their feet and do not guarantee long-lasting comfort. The survey also revealed that Malaysian women were not satisfied and faced many problems in choosing the right shoe size. These factors support the need for Malaysia to have its own shoe sizing system. The objective of this study is to replace the current shoe sizing system for Malaysian women to prevent a number of foot deformities and health problems.

II. MATERIALS AND METHODS

2.1 Data collection

All three major ethnic groups in Malaysia (Malays ($n = 710$), Chinese ($n = 368$) and Indians ($n = 132$)) participated in this study. The age of the participants ranged from 20 to 60 years. The average age for Malay participants was 37.36 ± 10.96 years, for Chinese participants was 37.24 ± 12.97 years, and for Indian was 36.91 ± 12.35 years. The mean of their stature and body height was 62.54 ± 28.89 kg and 155.97 ± 7.41 cm respectively. The data were collected for two years, from December 2013 to December 2015. In order to achieve the main purpose of the survey to identify the issues behind foot deformities influence by poor shoe fitting, a friendly questionnaires has been designed with short, concise, and limited to a certain number. The questionnaire had 10 questionnaires with 3 sections (Section A, B and C). Section A were about background information and demographic profile (age, weight, race, place of birth, occupation). Section B were about identify problems in foot deformities cause influence wearing wrong shoe size where the main section in this study and section C is about types of shoe shapes wearing every day. The study was approved by the University of Malaya Research Ethic Committee (UMREC) with an ethical clearance number UM.TNC2/RC/H&E/UMREC-63.

2.5 Statistical analysis

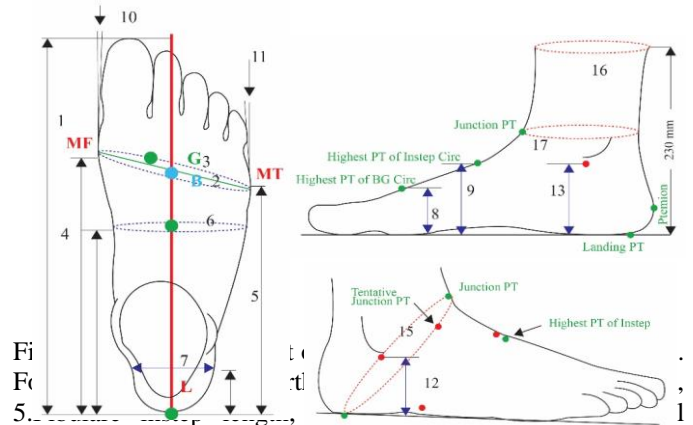
Statistical analyses were carried using SPSS version 16.0. Regression analysis in the form of Generalized Linear Model was performed on the data of the participants, giving attention to some attributes that might have association with the existence of the foot deformities. The response variable which was the presence or absence of foot deformities was regressed on seven attributes of the participants, that is, occupation, age, ethnicity, weight, height, FL, FB and BG. From these results, the parameters for the foot dimensions could also be derived and confirmed.

Since 3D scanning technique was found to be more precise and accurate than the manual measuring method [14,15], in this study, the INFOOT 3-dimensional (3D) foot scanner (INFOOT USB scanning system, IFU-S-01, I-Ware Laboratory Co., Ltd) was used was used to identify the Hallux vulgus by polygon mesh 3D image (Figure 1).



Figure 1: Scanning process using 3D INFOOT scanner

This high type INFOOT scanner has 6 lasers and 12 cameras. The high type INFOOT scanner can capture images of the foot until the calf area. It scans the foot form and anatomical landmark points automatically, capturing 17 measurements as illustrated in Figure 1.



breadth, 8. Height of top of ball girth, 9. Height of instep length, 10. Toe#1 angle, 11. Toe#5 angle, 12. Height sphyrion fibulare, 13. Height sphyrion, 14. Angle of heel born, 15. Heel girth circumference, 16. Calf circumference, 17. Horizontal calf circumference.

III. 3.0 RESULTS

3.1 Diversity of deformities among Malaysian women

Out of 1210 participants, we found that 135 women had problems in foot deformities such as hallux valgus (identified using 3D scanning), corn, cellules and ingrown toenail (Onychocryptosis) during the data retrieval process (Figure 3). Out of these 135, 61 (38%) of them experienced hallux valgus (Figure 4), 48 (35.8%) have corn (Figure 5), 19 (14.1%) have corn and cellules 7 (12.3%) have toe ingrown toe nail (Onychocryptosis) (Figure 6). A majority of the hallux valgus participants experienced mild or moderate deformities on both feet and only a few had severe one. Ingrown toenails existed on both or one of the participants' feet and most of them experienced inflammation at the edge of the nail, swelling and periungual corns. Corn and calluses were frequently identified on several areas such as the toes, heel and plantar area of the participants' foot. Some participants complaint about the pain and discomfort caused by the presence of corn and cellules when wearing shoes.

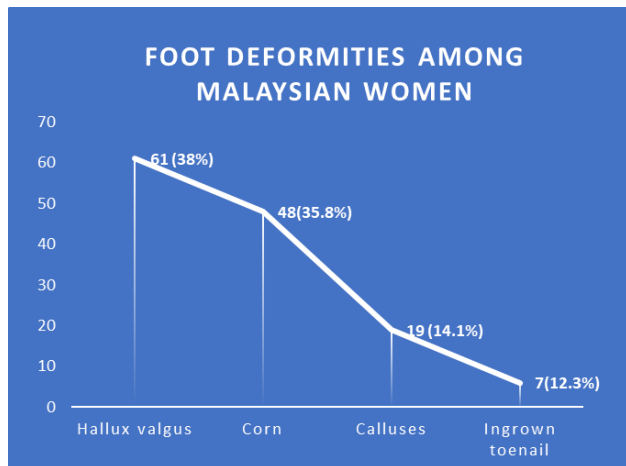


Figure 3: Foot deformities experienced by Malaysian women

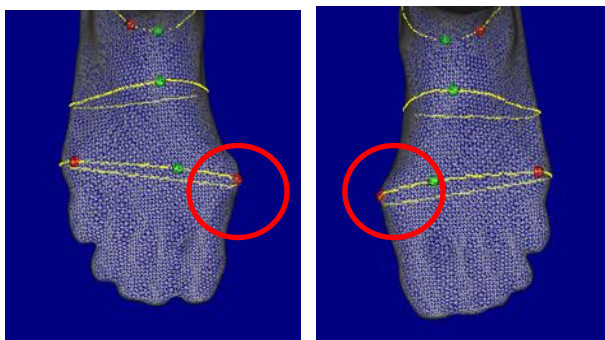


Figure 4: Hallux valgus deformity from polygon mesh 3D image INFOOT scanned data



Figure 5: Corn deformity



Figure 6: Ingrown toenail (Onychocryptosis) deformity

The results of the regression analysis (GLM) obtained at 5% significant level are shown in Table 1. It revealed that there was no significant association between foot deformities and the attributes age, height and ethnic groups of the participants. However, the presence of foot deformities is very significantly associated with weight of the participants (mean square = 2.329, $p = 0.000$). Hence, there is strong evidence that body weight has a significant impact on verities of foot deformities among Malaysian women. It is also obvious that among the three variables of foot parameters (FL, BG and FB), only FL and BG have significant association with the foot deformities (FL: mean square = .432, $p = .028$ and BG: mean square = .357, $p = .045$). While, 41.4% ($n=56$) preferred round shoe shape, 42% ($n=31.2$) preferred narrow shoe shape and 37(27.4%) prefere square shoe shape.

Table 1: Results of regression analysis
(Tests of Between-Subjects Effects)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.291 ^a	8	1.661	18.710	.000
Intercept	20.210	1	20.210	227.595	.000
Occupation	.212	1	.212	2.386	.123
Age	.027	1	.027	.303	.582
Ethnic	.000	1	.000	.002	.961
Height	.061	1	.061	.688	.407
Weight	2.329	1	2.329	26.226	.000
FL	.432	1	.432	4.863	.028
BG	.357	1	.357	4.018	.045
FB	.184	1	.184	2.071	.150
Error	106.647	1201	.089		
Total	4435.000	1210			
Corrected total	119.938	1209			

Dependent variable: Deformities

IV: DISCUSSION

This study revealed that out of 1210, about 11% of Malaysian women experienced some foot deformities (Hallux valgus, corn, calluses and ingrown toenail (Onychocryptosis)). Among these deformities, it was found that Hallux valgus is the most common. According to Perera [16], Hallux valgus is caused by genetics (a family history of bunions); however, tight shoes and improper shoe size fit can also be considered as possible factors. Some of the participants did report the presence of hallux valgus problems on their feet due to the wearing of inappropriate shoes sizes and shapes. [17], who suggested that the use of wider and roomier shoes could relieve pressure on the big toe (hallux valgus) and reduce pain, substantiates this statement. Besides bunion, corn and calluses are also widely suffered by Malaysian women. Mostly, the calluses occur are at the back of the foot, plantar arch, and anterior heel area (Figure 3). Corns are usually found on toes finger of participants because of too much pressure exerted, frequently by wearing high heels and tight shoes.

The findings of this study indicated that besides weight of participants, inappropriate FL and BG measurements are also factors which significantly contribute

to foot deformities. This proves that Malaysian women are not able to obtain shoe size that fits their feet. This is because they tend to have unique feet in terms of wider foot breadth and length of foot [18]. They do not have a choice in purchasing shoes that really suit their foot shape. For those who really prefer comfort, they have to order their shoes by taking an accurate foot size measurement. This is agreed by Chook Wah Soon, a shoemaker from Cheras Selangor, Malaysia who explained that he manually measures his customers' feet using a measuring tape. Despite the difficulty in obtaining the accurate size and comfortable fitting, it proves to be a service that has been rendered satisfactory by his customers [19]. Women in Malaysia should be more aware of getting the right shoe fit so that they are more comfortable on their feet.

For Malaysia, BG circumference is considered to be one of the important parameters used for the development of Malaysian women new shoe sizing system. Part of the problem faced by Malaysian women in choosing the right size of shoe is their larger average BG circumference. Therefore, the development of new standard shoe sizing system has been developed for Malaysian women with eight groups were proposed, that is a, b, c, d, e, ee, eee and eeee. The smallest proposed size for FL is size 4 and the biggest is size 11. which takes into consideration the proper and appropriate FL size and shapes for BG of Malaysian women is badly required to overcome this problem.

V: CONCLUSION

Among the foot deformities experienced by Malaysian women are Hallux valgus (38%), corn (35.8%), calluses (14.1%) and ingrown toenails (12.3%). These deformities are found to be significantly associated with the participants' weight, foot length and ball girth measurements. The FL and BG measurements from the current shoe sizing taking from US and UK is not suitable for our women feet, creating too many problems, starting from comfort to health. As a result of having proper and accurate measurements of these two parameters, a new sizing system has been developed based on 15 sizes (including the half size) corresponding to the foot length and eight shapes based on the ball girth groupings. With more accurate sizes and shapes, it is hoped that the foot deformities problem could be solved or at least reduced. These standards will provide useful and accessible information and guidelines to Malaysian women in terms of shoe comfort and correct fitting, reducing confusion for the customers when buying shoes.

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