

A Study on Anthropometric Dimension of the Foot amongst Undergraduate Students in Malaysia

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Abstract: The foot anthropometric data provides highly important information for anatomist, forensic scientist, physical anthropologist, health science, sports science & medical science professionals and also footwear industrial personals. The appropriate use of foot anthropometry data may aid in individual identification, assessment of health status, comfort and safety. The anthropometric variations not only depend on genetic inheritance, but also differs based on environment, geographical demarcations, ethnicities and cultures. Though some of the foot anthropometric studies are carried out in Malaysian population, but still a comprehensive foot anthropometry data among undergraduate students in Malaysia is limited. The study included 227 undergraduate students of AIMST University. Their age ranged from 18-25 years, with Malaysian citizenship. The data collection procedures followed was in accordance with the ethical standards of AIMST University committee. The FL measurements were carried out using digital sliding calliper (Mitutoyo, ABSOLUTE, Model No. CD-12" PSX, Serial No.0051322) with standard procedures and techniques. The FL measurement values were recorded in the nearest millimetre. All data were analyzed with SPSS trial version 22. The Independent T-test was used to analyze the difference in foot length between the right foot and the left foot of each gender. The socio-demographic data and the foot dimensions of the participants were described with descriptive analysis. The results showed that there were no significant differences between right foot length (FLR) with left foot length (FLL) in male feet but a significant different of right foot length (FLR) with left foot length (FLL) in female feet. The study showed no significant bilateral foot asymmetry in male foot but a significant bilateral foot asymmetry in female foot. The anthropometric data obtained in this particular study will not only help to establish the individual profile of the university student but also it will be of great value in practical applications and for further studies in this field.

Keywords: Anthropometry, Foot Length, Malaysian Population.

INTRODUCTION

The human foot is the terminal portion of a limb which bears weight and it is the foundation for bipedal locomotion. The human foot is an extremely complex mechanical structure, flexible and strong to provide a stable base to support the pressure of the body during erect stance and to provide propulsive and controlling force during locomotion in order to perform activities of daily living [1]. The foot structure description plays an important role for many reasons and the foot anthropometric data are highly important information for anatomist, criminologist, forensic scientist, human biologist and physical anthropologist, health and medical sciences, sports science and footwear industries [2, 3].

Today, the appropriate use of foot anthropometry data may aid in individual identification, assessment of health status, comfort and safety but it is

also important in epidemiology, evolutionary science, ergonomic and the latest is biometrics.

No two individuals are precisely alike in all their measurable traits, even genetically identical twins (monozygotic) differ in some respects. Anthropometric differences in foot dimension exist within and across both sexes [4]. A study conducted by Kanaani *et al.*, [5] concluded that 85% of foot dimensions have correlation with each other and the foot length has relation with age and concluded that a significant correlation between different parameters of foot on both right and left side in males and females. The individual variations are not only due to genetic inheritance, but also due to differences in the environment, socio-economic development, ethnicities, culture, influence the demographic variations [2, 5, 6].

The foot anthropometric data also plays an important role in finding the bilateral asymmetry of the human body [7]. Bilateral asymmetry of the human body is also known to affect stature estimation in forensic examinations [8, 2]. A study by found statistically differences between left and right foot but the foot length alone did not show bilateral asymmetry [9]. Another study in East Malaysia on Iban ethnic found no significant bilateral asymmetry was observed in both gender [10]. The study to observe the differences in the dimensions of the left and right feet of both genders in young adult demonstrated the incidence of bilateral asymmetry. Both males and females, the right foot is longer than left foot in both genders [4].

This study will contribute the data regarding anthropometric data of foot dimension amongst undergraduate students in Malaysia. The foot length can be used as an adjuvant in forensic medicine for individual identification and to assess the impact of it on movement performance, disability and injuries. The data of the recent study will provide baseline information and will become a reference for the future research and development, for medical practice as well as the footwear industries in Malaysia. The age; gender and ethnicity differences of anthropometric dimensions of the Malaysians would help to explain the individual structural characteristics [10]. Changes in lifestyles, nutrition, and ethnic composition of populations lead to changes in the distribution of body dimensions and require regular updating of anthropometric data collections. Though some of the foot anthropometric studies are carried out in Malaysian population, but a comprehensive foot anthropometry data among undergraduate students in Malaysia is still limited. Thus, there is a need to accumulate the foot anthropometric data or update the existing data.

MATERIALS AND METHODS

The cross sectional study was used to gather all the required data. The study was conducted in Anatomy Unit, Faculty of Medicine, Asian International Medical Science and Technology (AIMST) University, Kedah, Malaysia. A total of 227 AIMST students from various faculties irrespective of their study year or class were included in this study project. The inclusion criteria for this study were the students in AIMST University, Malaysian citizen, the age was between 18 to 25 years old, irrespective of the study year or class, without any congenital deformity and/or acquired deformity or/and other abnormality of the foot area. The

student did not have the past or present history of injury to the foot area and/or surgery of the foot area.

All subjects were given an information sheet and filled up and signed a consent form. The eligible student that meets the inclusion criteria will proceed with the anthropometric measurement procedures. The briefing was done to ensure student's safety and to avoid any error during methodology. They were advised to comply with the following instructions: to wash their feet with soap and water, to removed their shoes, socks, stocking, any foot support and any headgear, to remove any items from their shirt / blouse or trousers pockets, to use the stairs during getting up onto the measurement table and roll up their trousers, just below the knees.

One set of material consist of information document sheet, consent form, questionnaire sheet, data collection sheet and pen were kept at the registration station. An alignment board with lines (Figure-2) was used to ensure the foot was placed in a correct position during measurement procedure [11]. Measuring the distance of each foot dimension was taken with digital sliding caliper (Figure-4) 'Mitutoyo, ABSOLUTE, Model No, CD-12"PSX, Serial No.0051322' following the standard procedure. All the measurements was taken in well-lighted room. The space of the study area was arranged into two stations. Station one for registration and briefing, for participant to fill up the consent form and answering the questionnaires. Station two for measuring the FL. *The anthropometric measurement table* was set up to assist the right height while performing the measurement procedure as well as to ensure comfort for both the participants and the researcher. Hence, the researcher used one big wooden office table with the size of 72"x 36"x 32" (L x W x H) (Figure-1). To avoid errors that could be caused by discomfort or individual differences, a height adjustable swivel chair was used. The researcher utilized one wooden box (Box A) with small castor size 20" x 16"x 20" (L x W x H) as a platform for the foot to rest during measurement.

This box also serves a suitable ergonomic height for the researcher in order to avoid backache after prolongs procedures. Additionally, the researcher also utilized another wooden box (Box B) with the size of 20" x 16" x 8" (L x W x H). This wooden box was placed on the table top, in order to meet the standard sitting height 20".



Fig-1: Anthropometric measurement tile setting, (a) Office table, (b) Box A (C) Box B

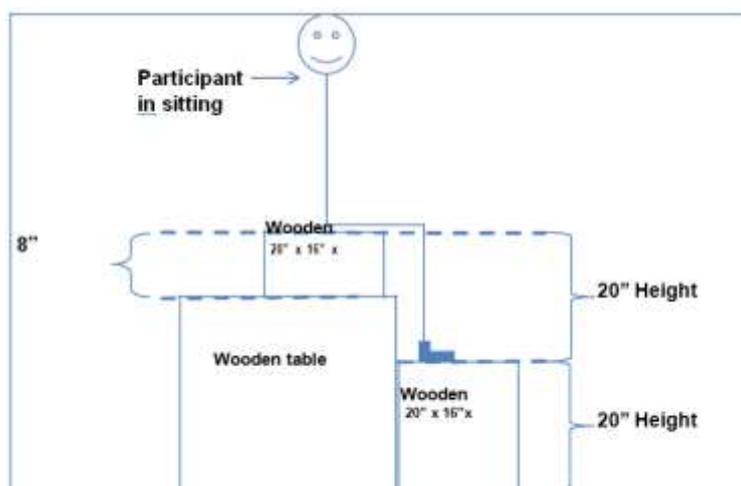


Fig-2: Measurement table setting

Foot parameter

Only the FL was considered in this present study. The Foot length is the distance measured from acropodian (the most forward projecting point on the toe) to pternion (the most backward projecting point on

the heel) Foot length was measured as a direct distance from the most prominent point of the back of the heel to the tip of the hallux or to the tip of second toe, when the second toe was larger than hallux by spreading caliper (Figure-3).

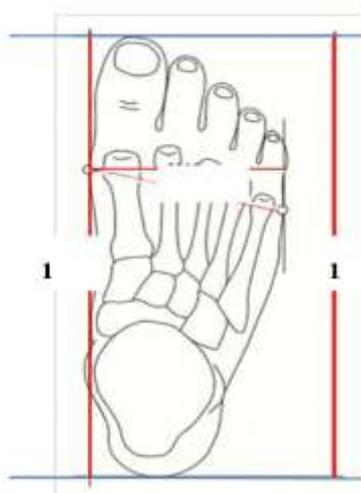


Fig-3: The foot parameters: Foot length

METHODS

The foot length was taken independently on the left and right side of the foot of each participant. All measurement was taken with a digital sliding calliper and was recorded in the nearest 0.1 millimeter. In this procedure, the measured foot was positioned accordingly as was described earlier but the other foot (non-measured foot) was instructed to place approximately 20 centimetres sideway. All foot measurement were repeated once until concordant values or until satisfactory values were achieved.

All measurements were taken in erect sitting position with no load on both feet and maintained both feet in position. The arms were to hang straight, but loosely, at the sides of the body with the palms

alongside, but not touching the thighs. Subjects were asked to look straight ahead and regularly remind them for not leaning forward or look down at the foot. The selected foot was placed on alignment board. The foot was position at right angle at the ankle joint [12].

To measure the FL, the calliper was horizontally place along the medial border of the foot. The fixed part of the outer jaw of the calliper is applied to the pternion and the mobile part of the outer jaw is then moved until they just made contact with the skin approximated to the acropodian. Once both jaws made contact with the skin, then the measurement value were taken and recorded in the data collection sheet. Measurements of the other side of the foot were taken in the same manner [13, 14].



Fig-4: Measuring foot length.

Statistical analysis

The data were analysed using SPSS trial version 22. Descriptive analysis was used to describe demographic data of participant and foot anthropometric measurement. The significant level was set at p value < 0.05. The data were collected, analysed and subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS). The FL and FB variable were in millimetre. The content validity has been done by researcher. The researcher selected convenience sampling. Sample size was calculated.

In this study, Z value is 1.96 for the level of confidence of 95%; P value is 0.15; d value is 0.05; as a result the minimum sample size (n) required is 196. This research project was successfully recruited a total of 227 participants. The ethical approval was granted and had an ethical approval from the AIMST University Human & Animal Ethics Committee (AUHAEC) AIMST University, dated 15th October 2014. This study was self-funded.

RESULTS

Table-1: The differences of right and left foot dimension in male and female

	Significant difference		No significant difference	
Males N = 64			FLR- FLL P value = 0.476	FBR- FBL P value = 0.563
Females N = 163	FLR-FLL	P value =0.000	FBR- FBL	P value = 0.375

From the statistical analysis result: No significant differences between right foot length (FLR) with left foot length (FLL) in male feet. The significant different of right foot length (FLR) with left foot length (FLL) in female feet.

DISCUSSION

The findings revealed there is no significant difference between right and left foot length in male,

but in females there is a significant difference of foot length between right and left foot in female (Table-1). Bilateral asymmetry is the difference between the measurements of the left and right sides of the human body and this subject has been studied by several authors.

Male – No differences: However another study on Western Australian population conducted by

revealed there was no significant difference of the right and the left foot length [15]. Similar results have been noted in the study conducted by in a comparative study of various foot dimensions between adult male and females in Bengalee (Indian) population, they found there was no significant difference in the foot length between left and right male foot [16]. Another study conducted by on young-adult Nigerian population also showed no significant difference in foot length between right and left male [4]. A study conducted for foot length of adult Bangladeshi male found no significant difference of foot length of both feet [17]. The studies conducted by several other researchers on foot length measurement showed no significant differences between the left and right foot length in male. A study conducted by Krishan & Sharma for estimation of stature from dimensions of feet and hands in a North Indian population [18]. The statistical analyses indicated that the bilateral variation was insignificant for all the foot length measurement in male. A study of foot anthropometric measurements in Arizona, United States of America in order to predict dynamic plantar surface contact area indicated that there were no significant differences between the left and right foot length in male [12]. A study conducted by among adults of the Melanau ethnic group in Sarawak, East Malaysia showed no significant bilateral foot asymmetry in male [19]. A similar study on analyzing the footprint length dimension among the adults of the Iban ethnic group in Sarawak, East Malaysia, also showed no significant bilateral foot asymmetry in male [10].

Male - Differences: However another study on Western Australian population conducted by revealed a significant difference of the right and the left foot length of male [15, 20]. Estimation of stature from foot length and foot breadth among the Rajbanshi of North Bengal, showed significant difference between right and left foot length in male. Similar finding was noted in another study by Krishan, he measured for ten measurements from bilateral footprints and eight measurements from foot outlines of each individual in Gujjars of North India. The results indicated that the foot length in foot outline show statistically significant bilateral asymmetry in male [21].

Female – No differences: However another study on Western Australian population conducted by Hemy *et al.*, revealed there was no significant difference of the right and the left foot length in female [15]. A study conducted by Krishan & Sharma [18] for estimation of stature from dimensions of feet and hands in a North Indian population. The statistical analyses indicated that the bilateral variation was insignificant for all the foot length measurement in female [18]. Krishan *et al.*, [9] has conducted a study on the estimation of stature from the foot and its segments in young females in North India. Foot length

measurements did not show any statistically significant bilateral asymmetry of both feet [19]. A study conducted by Hairunnisa & Nataraja Moorthy [19] among adults of the Melanau ethnic group in Sarawak, East Malaysia showed no significant bilateral foot asymmetry in female. A similar study on analyzing the footprint length dimension among the adults of the Iban ethnic group in Sarawak, East Malaysia, also showed no significant bilateral foot asymmetry in female [10]. In another study conducted by Krishan *et al.*, in estimation of stature from the foot and its segments in North Indian population, showed no significant bilateral asymmetry in foot length measurement in female [9].

Female – Differences: Similar results have been noted in the study conducted by Manna *et al.*, in a comparative study of various foot dimension between adult male and females in Bengalee (Indian) population, they found there was a significant difference in the foot length between left and right female foot [16]. Another study conducted by Ewunonu *et al.*, on young-adult Nigerian population also showed a significant difference of foot length between right and left female foot [4, 20]. Sen and Ghosh [20] for estimation of stature from foot length and foot breadth among the Rajbanshi of North Bengal, showed significant difference between right and left foot length in female. Similar finding was noted in another study by Krishan he measured for ten measurements from bilateral footprints and eight measurements from foot outlines of each individual in Gujjars of North India [21]. The results indicated that the foot length in foot outline show statistically significant bilateral asymmetry in female [21].

Possible reasons and explanations for the differences in finding: Measuring techniques: The difference in the findings among various researches may be due to variation or lack of standardization in the identification of measurement site and in measurement techniques [13]. It may be due to an inconsistency in measuring methods, such that the actual foot joint orientation and amount of load undertaken were different and different definitions of measuring parameters [22]. Hereditary/genetic and environment: The various body measurements including the foot are bound to show regional and ethnic variations due to heredity and various environmental conditions [23].

The timetable of development is influenced and controlled by many genetic and environmental factors. Any disturbance in the normal sequence of development and growth may lead to disproportion of physical features [14]. The foot length elements are affected by individual and racial differences [24]. Another reason for the difference in the measurements of foot dimension in the humans demonstrates species-wide bilateral asymmetry in long bone dimensions. A

mixture of influences from both genetic and behavioural factors has been reported by Auerbach & Ruff [25]. Because of geographical variations in the morphology of different population group [26].

Laterality: Other reason for the difference in the measurements of the left and right feet in the present report seems to be supported by the behavioral studies of lower limb laterality (dominant leg) which consistently indicated higher frequencies of right-footedness [27]. This could be true where the effect of footedness was task context specific in which the footedness is exploited as a function of task asymmetry [28]. Ewunonu *et al.*, stated that the bilateral asymmetry can be explained by the effects of cerebral dominance on lateral preference for the right foot on the basis of the fact that majority of persons put greater strain on the left lower limb for stability than on the right in weight bearing and in walking and as a result of genetic factors [4]. A literature reviewed by Sadeghi *et al.*, on symmetry and limb dominance in able-bodied gait in order to investigate how limb dominance affects the symmetrical or asymmetrical behaviour of the lower extremities [29]. The literature reviewed shows that asymmetrical behaviour of the lower limbs was found to reflect natural functional differences between the lower extremities. The footedness may influence the changes in foot biomechanics which eventually may cause changes in foot morphology. Biomechanic: Since the foot is playing an important role in locomotion, so that the foot structure is under dynamic loads and plantar pressure. This is considering the biomechanical factors which may affect the plantar foot shape [30]. The study of quantitative comparison of foot anthropometry under three different weight bearing conditions, revealed that increasing the weight bearing on a tested foot show very significant increase in foot length [31]. Footwear: The differences of foot shape also may be due to the footwear design. In normal human growth, foot shape and proportions change progressively, however a key factor for foot development are mechanical stresses during bipedal locomotion. A proper fit of footwear is important, not constraining foot growth and allowing a normal development [6].

CONCLUSION

The anthropometric data presented in this study constitute the basis of foot anthropometric database of a small population of the university students in Malaysia. The foot length of the right foot and foot length of the left foot were measured from each gender and the values are summarized in this study. The study showed a significant bilateral foot asymmetry in female but no a significant bilateral foot asymmetry in male with majority of them presented with the right foot dominance. This anthropometric data will not only help to establish the individual profile of the university

student but also will be of great value in practical applications. The study reveals the necessity for further comprehensive research in this field in order to obtain a significant anthropometric database considering the Malaysian ethnic diversity, cultural diversity and environmental factor. The foot anthropometric data's obtained in this study will be highly useful for anatomist, forensic scientist, physical anthropologist, health science, sports science & medical science personals and also for footwear industrial personals, moreover this data can serve as a reference for future studies.

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