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Foot Anthropometry of 18-25 Years Old Iranian Male Students

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Abstract: The objective of this study is to determine the foot anthropometric data's for some Iranian men to apply in medicine and design of foot equipments. In this study, the foot images of 160 Iranian men, with ages ranging from 18 to 25 years old were taken by a digital camera and the values of 8 dimensions of the foot were extracted with software for each individual. Finally the results were analyzed by SPSS. The average values, standard deviation, the smallest and largest values, the 5th, 50th and 95th percentiles of the 8 dimensions were calculated. For example Mean±SD for length, width and Biomlleolar Breadth of the foot were obtained 264.66±13.10, 106.84±5.64 and 74.47±4.11 mL. The correlation coefficients were found between different dimensions. It was determined that there is significant correlation between 85% of foot dimensions ($p<0.05$). In this study, for the first time the values of 8 important foot dimensions were obtained in Iran that will serve as a basis for design and sizing of shoes and other foot equipments. It is recommended that similar studies to be done with considering race, life style and job for the purpose of medical goals and ergonomic designs.

Key words: Foot, anthropometry, health, medicine, dimensions, measurement, shoes

INTRODUCTION

Anthropometry consists on the measurement of body dimensions such as reach, length, width and heights. This information can be used to design tools, equipment, work stations and clothes. Appropriate use of anthropometry in design may improve well-being, health, comfort and safety (Pheasant, 1998; Moudi, 1996). Shoes are the important equipments that are essential need for people. For suitable design of shoes, foot dimensions of consumers are required. Length, widths and heights of feet should match with shoes in order for footwear to be comfortable (Monica *et al*., 2005). The feet are very complex in that each foot has 26 bones and these bones make up 33 joints. Considering the entire body has 206 bones, both feet have almost one quarter of the bones in the body. In addition these bones forming the joints are held together with layers of 126 muscles and ligaments. The muscles and ligaments are augmented with a great many nerves. The ankles do not have any muscles and can become weakened due to over-stretching of the tendons and ligaments. Trauma due to sprains/strains and repetitive motion injuries can further weaken the ankles and feet. The small size of these complex structures, in relation to the rest of the body and the fact that they are the supportive foundation of the entire body, places an enormous burden upon them. Every step we take and the ensuing pounding places an additional amount of weight

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and throughout the day can amount to many tons of weight that the feet are subjected too. This constant pounding, usually aggravated by improper footwear, leaves no doubt as to why most individuals will suffer some form of pain in either one or both feet (Cheng and Perng, 1999; Meister, 1971). Human feet are changing during the life time that most of them are preventable by wearing fitted and standard shoes (Browne *et al*., 1990; Yazdchi, 2007). For supporting the feet structure, finding the ergonomic shoes are very important. Wearing unfitted shoes leads to foot disorders, mental impacts, dexterity reduction, comfort reduction, increasing energy consumption and decreasing the subject efficiency for doing tasks (Simon, 2004). There are many studies on foot anthropometry to use in sizing foot, making shoe last and determining the correlation between the foot dimensions (Cheng and Perng, 1999; Goonetilleke *et al*., 2003; Channa *et al*., 2006). A study was done about Foot Anthropometry in Hong Kong. Even though numerous devices are available for measuring the foot, generally, only one or two dimensions are used when sizing a foot. The study attempts to find orthogonal dimensions so that a Hong Kong Chinese foot may be properly sized and modeled. Factor analysis and principal component analysis indicated that the height dimension is important. Hence, it is recommended that at least two dimensions be measured in the forefoot, midfoot and rearfoot to model the foot better (Goonetilleke *et al*., 2003). Foot measurements from three-dimensional scans have done for comparison and evaluation of different methods, Simulated Measurements (SM), commercially available automated foot measuring system (CP) and Manual Measurements (MM). The results showed that there were no significant differences between the SM and MM methods for 17 of the 18 foot dimensions and the single exception was the heel width dimension (Channa *et al*., 2006). Comparative anthropometric analysis of shod and unshod feet, determined that wearing shoe can affect the transmission of forces during locomotion. This can be both in the dynamic and the static settings. Most shoes have an inbuilt medial arch support and toe boxes that are narrower than the true width of forefeet wearing them. This may result in incomplete accommodation of the dynamic correlates of the transverse and longitudinal arches of the foot leading to stiffer feet that may have a negative influence on their functional capability. This study showed that although shoe wearing does not affect the intrinsic forefoot muscle strength, it is appeared to result in stiffer forefeet (Kadambande *et al*., 2006). A systematic approach for developing a Foot Size Information System (FSIS) for shoe last design was established in Taiwan. This study contributes the designers in grading information that is helpful for shoe last design. The FSIS provides the basic information for design and manufacturing of shoe lasts. The information can be used as a guideline to evaluate and determine the feasible parameter for shoe last design and manufacturing, especially developing the reasonable and comfortable shoe last and foot wear (Cheng and Perng, 1999). In anthropometric study of Norwegian light industry and office workers, some foot dimensions were measured to design personal safety shoes (Bolstad *et al*., 2001). The anthropometric data of the adult Iranian population is limited. The first anthropometric study of Iranian was done in male soldiers for military design and sizing the boots in 1967, but no information has been issued about the results (Moudi, 1996). Up to now there has not been any special foot anthropometry in Iran. While this is one of the important problems of shoe designers and makers in this country. So, they ought to use anthropometric data's of other nations in designing and sizing the shoes. New methods of anthropometric data collection that allow data to be collected quickly and accurately, such as the use of computerized procedures, provide new opportunities for anthropometric study

(Paquette, 1996; Roebuck, 1995). The aim of this study is to determine anthropometric dimensions of foot for a small sample of Iranian student male.

MATERIALS AND METHODS

Subjects

One hundred sixty males' feet were measured. The method of determining the sample size is explained in statistical analysis. This method was done by helping a statistics expert. The sample comprised Iranian students from Health School of Beheshti (Melli) Medical University. This research project was conducted from 10-May-2007 to 22-Aug-2007. Aged varied between 18 and 25 years old. As most of Iranian students are in this age range and the dimensions of the individual skeletal structure has its maximum development up to the age of 18-25 years old, so these age group males were selected. None of them had any visible foot abnormalities or foot illnesses.

Range of Foot Dimensions Measured

A total of eight dimensions of foot were recorded for each individual: foot length, foot breadth, biomalleolar breadth, heel breadth, instep length, height of MPJ at the first toe, foot height (dorsal arch height) and ankle height.

Equipment used

The measurements were obtained by a Canon-A530 portable digital camera with the minimum resolution of 5 M pixel, a camera holder, a foot place, two scales, photo anthropometry software and an adjustable bench.

Digital Photography Method

One operator took pictures from each person's right foot. Each subject was asked to take off his shoes and socks and sit on an adjustable bench and put his right foot on the foot place with equal weight on each foot. The foot was set on foot place so that the center line joins the pternion (posterior point of the heel) to the tip of second toe. The measurer took picture from up, back and sides of the foot by digital camera after installation scales (Fig. 1). Each photo is stored and analyzed subsequently in a computer. The images were opened in the designed software and linear dimensions were measured (Fig. 2). The analysis of images is as following: the user determines the pixels of 10 mm of the scale then clicks on the image points. For a better accuracy of the selected point a zoom window is available. The computation of the final value for the measure is automatically obtained by pixel counting. The computed measures for dimensions are shown by mm in software Table.

Statistical Analysis

First of all, 20 subjects were selected randomly and measured as a pilot to determine the sample size. The data gathered were automatically stored on a database in computer and were recorded and fed in to SPSS for statistical analysis. Means and standard deviations were calculated for each dimension in pilot study (Table 2). The sample size was computed 160 subjects with considering 2 mm as the error value according to the studies of Monica and Hwang. As Iranian are also Asian so the results of Asian studies can be used. One hundred and sixty subjects were chosen randomly. Then foot anthropometry of main samples were

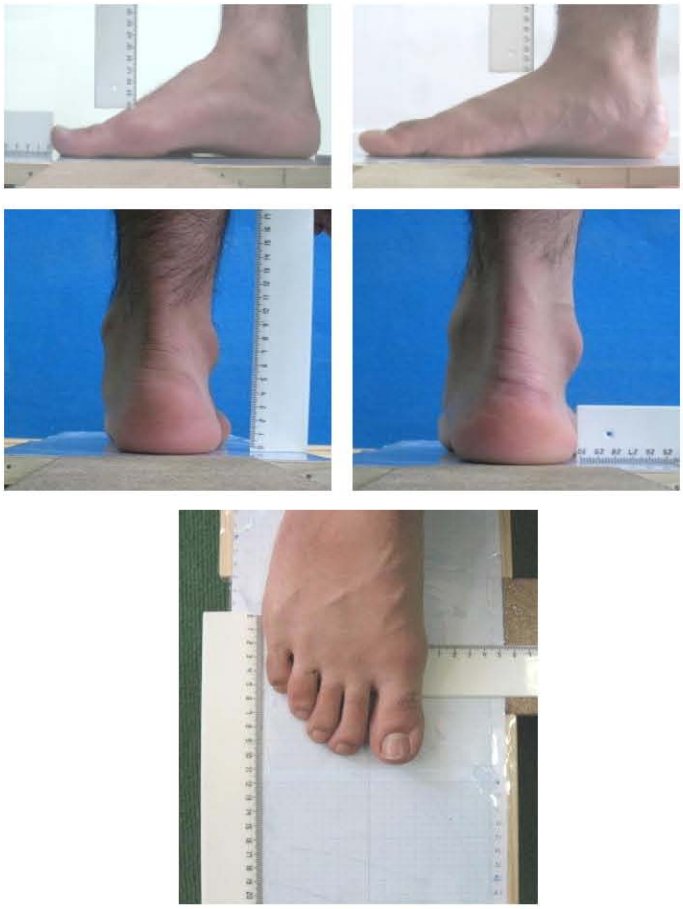

Fig. 1: The location of foot on the foot place for anthropometry

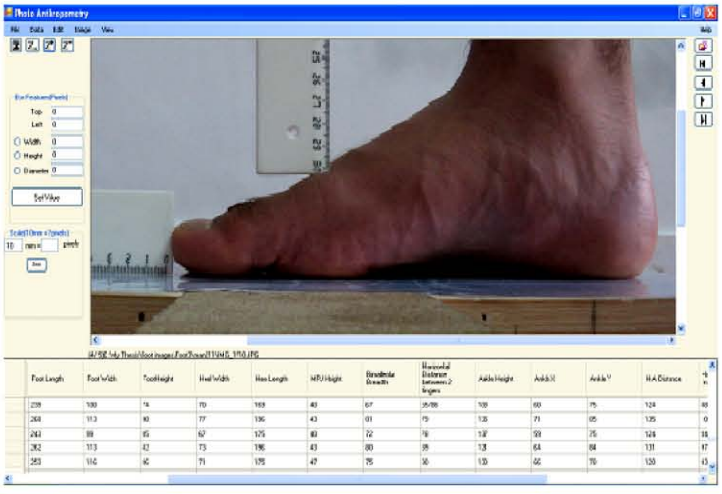

Fig. 2: The designed photo anthropometry software

done and the data's were recorded and fed in to SPSS for statistical analysis to calculate the average values, standard deviation, the smallest and largest values, the 5th, 50th and 95th percentiles of the 8 dimensions and correlation coefficients.

RESULTS

Table 1 shows the age distribution of the sample. Table 2 shows the values obtained for average and standard deviations of eight anthropometric dimensions measured in pilot study.

Table 3 shows the values obtained for mean, standard deviations, minimum and maximum of eight anthropometric dimensions measured in whole samples. Table 4 shows the values obtained for the 5th, 50th and 95th percentiles. Table 5 shows the correlation coefficients obtained between the foot dimensions analyzed.

Table 1: Age distribution of subjects (n = 160)

Age group (years)	Percentage	Numbers
18	18	11.2
19	21	13.1
20	19	11.8
21	18	11.2
22	21	13.1
23	21	13.1
24	19	11.8
25	23	14.3

Table 2: Mean and standard deviation for anthropometric foot dimensions of the pilot group (n = 20), values in mm

Foot dimensions	SD	M
Foot Length (FL)	261.60	12.080
Foot Width (FW)	106.70	5.250
Foot Height (FH)	81.20	5.380
Heel Breadth (HB)	73.80	4.620
Instep Length (IL)	188.10	10.890
Height of MPJ (HM)	42.05	2.960
Biomlleolar Breadth (BB)	75.50	5.190
Ankle Height (AH)	127.85	11.037

Table 3: Mean (M), standard deviation (SD), minimum (Min) and maximum (Max) for anthropometric foot dimensions (n = 160), values in mm

Foot dimensions	M	SD	Max	Min
Foot length	264.66	13.10	305	231
Foot width	106.84	5.63	120	86
Foot height	82.25	5.58	96	70
Heel breadth	71.97	4.27	83	63
Instep length	189.95	10.92	217	165
Height of MPJ	42.83	3.23	52	35
Biomlleolar breadth	74.47	4.11	86	66
Ankle height	127.44	8.80	156	104

Table 4: Percentiles for anthropometric foot dimensions (n = 160), values in mm

Foot dimensions	Fifth percentile	Fifth percentile	Ninety-fifth percentile
Foot length	243.05	265	286.95
Foot width	97.05	107	115.95
Foot height	73.00	82	91.00
Heel breadth	65.00	72	80.00
Instep length	170.00	190	206.00
Height of MPJ	38.00	42	48.95
Biomlleolar breadth	68.00	74	81.00
Ankle height	114.05	127	141.95

Table 5: Matrix of the Pearson correlation coefficients obtained between the anthropometric foot dimensions analyzed (n = 160)

Foot dimensions		AH	HD	BB	MH	HL	HW	FH	FW	FL
FL	Pearson correlation	0.331**	0.210**	0.391**	0.083	0.936**	0.412**	0.197*	0.464**	1
	p-value	0	0.008	0	0.294	0	0	0.013	0	-
FW	Pearson correlation	0.309**	0.674**	0.463**	0.429**	0.413**	0.461**	0.436**	1	0.464**
	p-value	0	0	0	0	0	0	0	-	0
FH	Pearson correlation	0.355**	0.279**	0.263**	0.575**	0.109	0.184*	1	0.436**	0.197*
	p-value	0	0	0.001	0	0.17	0.02	-	0	0.013
HW	Pearson correlation	-0.002	0.385**	0.567**	0.349**	0.423**	1	.184*	0.461**	0.412**
	p-value	0.977	0	0	0	0	-	0.02	0	0
HL	Pearson correlation	0.251**	0.175**	0.364**	-0.064	1	0.423**	0.109	0.413**	0.936**
	p-value	0.001	0.027	0	0.422	-	0	0.17	0	0
MH	Pearson correlation	0.153	0.383**	0.377**	1	-0.064	0.349**	0.575**	0.429**	0.083
	p-value	0.054	0	0	-	0.422	0	0	0	0.294
BB	Pearson correlation	0.380**	0.386**	1	0.377**	0.364**	0.567**	0.263**	0.463**	0.391**
	p-value	0	0	-	0	0	0	0.001	0	0
HD	Pearson correlation	0.184*	1	0.386**	0.383**	0.175*	0.385**	0.279**	0.674**	0.210**
	p-value	0.02	-	0	0	0.027	0	0	0	0.008
AH	Pearson correlation	1	0.184*	0.380**	0.153	0.251**	-0.002	0.355**	0.309**	0.331**
	p-value	-	0.02	0	0.054	0.001	0.977	0	0	0

**Indicates that the value is significant at the 0.01 level. *Indicate that the value is significant at the 0.05 level

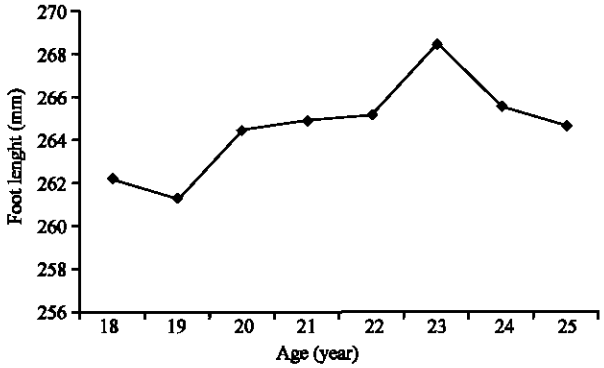

Fig. 3: Foot length (mean value in mm) for the age groups defined

DISCUSSION

The sample used includes subjects from 18-25 years old male students from Shahid Beheshti university of Iran. Figure 3 shows the average values obtained for foot length in defined age groups. Table 3 shows the Mean±SD, minimum and maximum values of foot dimensions. For example the average value of foot length is 264.66±13.1 mm and maximum and minimum foot lengths were 305 and 231 mm in this study. According to Table 4 with considering the 5th and 95th percentiles, the range of each foot dimension includes the 90% of the society. Results obtained regarding the correlation coefficient between the different dimensions (Table 5) indicate that approximately 76% of the values obtained are significant at 1% level, that circa 9% of the values are significant at 5% level, the remainder 15% being non-significant. In other hand 85% of the foot dimensions have significant correlation with each other. Figure 1 shows that maximum average value of foot length is for age group 23 and minimum value is for age group 19. It can not be said that the foot length has any relation with age, because this value for age group 18 is more than age group 19 and also for age groups 24 and 25 is less than age group 23. Of course we can say

Table 6: Mean (M), standard deviation (SD), minimum (Min) and maximum (Max) for anthropometric foot dimensions of Chinese men, values in mm

Foot dimensions	M	SD	Max	Min
Foot length	246.7	12.3	271	226
Foot width	96.4	7.4	108	84
Instep length	179.3	9.5	197	164
Heel breadth	63.5	4.0	72	57
Foot height	58.6	5.6	67	49

that the men born in 1984 have the largest feet among the men born in 1982-1989. In other hand the men born in 1988 have the smallest feet among the men born in 1982-1989. It may be described as change in body growth (evolution). Underlying this fact might be the recent improvements registered in Iranian quality of life. So it is necessary to find the reasons of this body growth changes in people born in different years of last two decades with considering the impacts of nutrition condition, doing sports and so on. With regarding to the increasing usage of Chinese clothes and specially shoes in our country, in order to compare the foot dimension values in these two nations, the results of foot anthropometric study of Chinese men in ages 19-23 years old that has done by Channa and *et al.* (2006) has shown in Table 6. Comparison the results of 5 foot dimensions anthropometry in 18-25 year old Iranian men with 19-23 year old Chinese men, indicated that the values of foot dimensions for Iranian men are larger than Chinese men. For example, for Foot length, the difference found are those registered between the Iranian and the Chinese population 264.66 and 246.7 mm for male populations. Based on these results, it is obvious that using of equipments that have been designed for Chinese, are not proper for Iranians. The differences found in the anthropometric dimensions of the different populations emphasize the usefulness of this study and the results presented herein.

CONCLUSIONS

Eight foot measurements of Iranian students were summarized in this study. This will be of great value for the design of foot equipments. The anthropometric data presented in this study constitute the first foot anthropometric database of a small society of Iranian men that can be apply in ergonomic design and sizing of shoes and boots. Although, this anthropometric data will be of great value in practical applications, it should be noticed that these are static anthropometric measures. Therefore, the use of such data in design of equipment, tools and workstations, in which functional anthropometric data is needed, must be done considering the differences between the two referred types of anthropometric data. According to the great application of shoes and boot, there is a need to enlarge the sample size, not only in terms of age range, namely to compensate for the low frequency observed below 18 and above 25 years old, but also to encompass different occupational groups, such as industrial workers, farmers, fishermen and construction workers, for children, women and different Iranian races. We hope these data constitute the basis for a larger study once in 10 years, to be undertaken in order to obtain a significant Iranian anthropometric database about their other body dimensions to design required ergonomic equipments, tools, clothes, work stations, work places and homes. We also expect to be able to analyze the data in order to detect changes and/or any particular evolutions in the values of some dimensions between generations with considering the effects of race, air condition, living area, life style, nutrition, diet program and kind of job on human body dimensions for medical goals in a few years.

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