

A CROSS SECTIONAL STUDY ON SELECTED DIMENSIONS OF FOOT IN ADULT BANGALEE AND CHAKMA FEMALES OF BANGLADESH

Sharmista Bhattacharjee^{1*} Md. Ashrafuzzaman² Laila Razzaque³

Abstract

Background: Foot dimensions show variations between ethnic groups. Anthropometric study of foot dimensions of various ethnic groups is required to establish the ethnic identity of an individual. It also helps in accurate designing of workstations, equipment, footwear, orthotics, insoles, prosthetics etc. The aim of this study was to compare the foot dimensions of Bangalee and Chakma females of Bangladesh to find out their unique ethnic characteristics.

Materials and methods : It was a cross sectional, observational study. Two hundred Bangalee and two hundred Chakma adult females were recruited from Chattogram city. Height and foot dimensions of the participants was taken with a measuring tape and slide caliper.

Results: The foot length of Bangalee and Chakma females were 22.91 ± 0.79 cm and 23.11 ± 0.78 cm respectively. The foot breadth of Bangalee and Chakma females were 8.55 ± 0.40 cm and 9.22 ± 0.48 cm respectively. The t test showed statistically significant difference between adult Bangalee and Chakma females in terms of FL (Foot length) and FB (Foot breadth). The foot height of Bangalee and Chakma females of Bangladesh were 6.38 ± 0.55 cm and 6.32 ± 0.39 cm respectively. FH (Foot height) showed no significant difference between the ethnic groups.

Conclusion: The results of this study should be useful in ergonomic design and forensic investigations.

Key words : Foot dimensions; Bangalee; Chakma; Forensic and ergonomics.

Introduction

Anthropometry is the study of morphological variations in populations which is obtained by systematized measuring techniques. Determination of ethnic identity has always been a major concern for forensic experts, archaeologists and biologists. Metric analysis is a proven and useful tool for that

purpose. An individual's ethnic connection can be assessed by comparing anthropometric data from other populations.^{1,2} The advent of modern technologies have enabled better metric analysis and preservation of huge amount of morphological information. These anthropometric data can be used to design tools, equipment, workstations etc to ensure well-being, comfort and safety in working places.³ Foot is a complex and multi-segmented structure. Foot requires to absorb shock and mold itself according to the actions it performs and the supporting surfaces on which it performs the actions. These functional demands may contribute to structural abnormalities and injury of foot.⁴ Anthropometric measurements have been applied often in clinical settings to offer insight into those problems. In modern society, footwear became a necessity as well as a fashion accessory. Inaccurately designed footwear is acknowledged as the leading cause of foot pain and deformity. These problems are also relevant to Bangladeshi women. Quantitative assessment of foot is important for designing footwear, orthotics, insoles and prosthetics.^{5,6} 98 percent of the Bangladeshi population is comprised of the Bangalee ethnic group. The Chakmas residing in the Chittagong Hill Tracts are the second largest ethnic group of Bangladesh after Bangalees.^{7,8} Though evaluation and comparison of foot morphology is important for identification, designing and treatment purposes, there is limited information to bridge these gaps regarding the females of Bangalee and Chakma ethnic groups of Bangladesh. So, females of these two ethnic groups were chosen for present study to evaluate the differences in their foot dimensions.

Materials and methods

This was an observational, cross sectional study that included 200 Bangalee and 200 Chakma adult females of 18 to 44 years of age, residing at different locations of Chattogram city. Each participant was asked to stand upright so that each foot would carry 50% of the body weight. A steel board was placed on the head and the maximum height was

1. Assistant Professor of Anatomy
Marine City Medical College, Chattogram.

2. Professor of Anatomy
Chittagong Medical College, Chattogram.

3. Assistant Professor of Anatomy
Shaheed M. Monsur Ali Medical College, Serajganj.

*Correspondence: Dr. Sharmista Bhattacharjee
E-mail: sharmista201@gmail.com
Cell : 01715 50 18 60

Submitted on : 17.04.2020

Accepted on : 30.06.2020

marked on the wall. The stature was then measured in centimeters from the floor to the mark on the wall with measuring tape. Weight of the subject was measured by weighing machine and Body Mass Index (BMI) was calculated. Those who had a history of operation or deformity of lower limb, any genetic, endocrine, neurological disorders and a BMI > 24.9 kg/m² or <18.5 kg/m² were excluded from the study. Then each selected participant was measured for right and left feet. The data from both feet were pooled for statistical analysis of foot variables. Foot Height (FH) was measured from the most prominent point of medial malleolus of the tibia to the sole of the foot along the medial aspect of the leg by using a measuring tape.⁹ Foot Length (FL) was measured along an imaginary line drawn from the posterior prominence of the heel, to the tip of the longest toe. In some people, the first toe is the longest, in other people, the second toe is the longest.⁹ Foot Breadth (FB) was measured as the distance between the most medial points on the head of the first metatarsal to the most laterally placed point on the head of the fifth metatarsal.⁹ A manual sliding caliper was used to measure all the foot dimensions. SPSS software was used to analyze the data. Necessary permission was obtained from the concerned department and ethical review committee before the study.

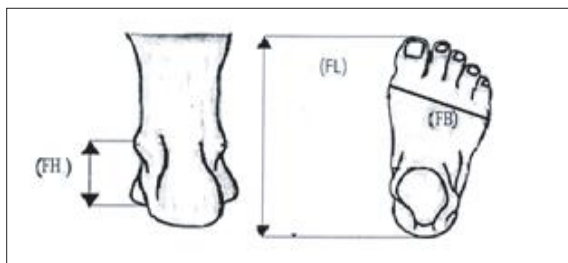


Fig 1 : Diagrammatic representation of selected foot measurements (Source: Modified from Parham et al. 1992; 32-33).¹⁰ FH-Foot Height FL-Foot Length DORS-Height of the Dorsum FB-Foot Breadth.

Results

Table I showed the demographic characteristics of the subjects of the both ethnic groups under evaluation. The mean value of age, weight and BMI of the Bangalee females exceed that of the Chakma ethnicity by 1.22years, 0.72 kg and 0.4 (kg/m²) respectively. In respect of mean height, the Chakma females exceed the Bangalee females by 0.42 cm. In all the four categories, differences between means were not significant.

Table I : Comparison of demographic characteristics of Bangalee and Chakma ethnic groups.

Variable	Bangalee (n=200)		Chakma (n=200)		t value	Significance (2 tailed)
	Mean	SD	Mean	SD		
Age (Yr)	27.46	7.36	26.24	8.1	1.5765	0.1157 NS
Height (cm)	155.03	5.41	155.45	4.78	0.8228	0.4111 NS
Weight (kg)	50.69	6.08	49.97	6.78	1.1181	0.2642 NS
BMI (kg/m ²)	21.46	2.08	21.06	2.38	1.7897	0.0743 NS

BMI-Body Mass Index, NS-Not Significant.

Table II presents the mean, standard deviation and ranges of selected foot variables of Bangalee and Chakma adult females. The Chakma females have greater mean values for all variables than Bangalee females except for foot height.

Table II : Descriptive statistics of selected foot variables of Bangalee and Chakma adult females.

Variables (cm)	Bangalee (n=200)			Chakma (n=200)				
	Mean	SD	Range		Mean	SD	Range	
			Min.	Max.			Min.	Max.
FH	6.38	0.55	4.95	8.30	6.32	0.39	4.75	7.45
FL	22.91	0.79	19.95	25.15	23.11	0.78	20.30	25.00
FB	8.55	0.40	7.25	9.70	9.22	0.48	8.00	10.55

● FH-Foot Height DORS-Height of the dorsum at 50% foot length FL-Foot Length FB-Foot Breadth. Min-Minimum, Max-Maximum.

Table III presents the comparative analysis of foot variables between Bangalee and Chakma adult females. The t test significance showed highly significant difference in case of FB (Foot Breadth). FL (Foot Length) presented significant differences in mean values whereas in FH (Foot Height) adult Bangalee and Chakma females showed no significant difference.

Table III : Comparison of selected foot variables between Bangalee and Chakma adult females.

Variables	Difference of means of study groups	SED	95% CI of differences		t value	Significance (2 tailed)
			Lower	Upper		
			FH	0.0573		
FL	0.2021	0.078	-0.3495	-0.0427	2.5127	0.0124*
FB	0.6708	0.044	-0.7577	-0.5838	15.1729	0.0001***

● NS (p > 0.05) = Not significant, (p < 0.05)* = Significant, (p < 0.001)*** = Highly significant.

● FH-Foot Height, DORS-Height of the dorsum at 50% foot length, FL-Foot Length, FB-Foot Breadth, SED-Standard Error of Difference between means, CI- Confidence Interval.

Discussion

Three dimensions of the foot including height and weight of the subjects were measured. In the present study, the age range of the participants was kept within the range of 18-44 years. Foot growth usually ceases between 13 to 15 years of age in females.¹¹ Minimum age of all the subjects selected was set at 18 years (Instead of 15) to allow for any growth that may happen prior to that age. It was observed that the frequency of structural foot disorders among adults over 50 years of age was high and menopause leads to loss of bone mass.¹² So, the maximum age of the participants was set at 44 years to exclude those issues. Obesity is associated with detrimental changes to foot structure and function. Obese women show increased fore-foot width which is indicative of laxity of ligaments.¹³ This effect of obesity on foot structure was taken into account on setting the BMI of the participants within the World Health Organization approved range of 18.5-24.9 kg/m².¹⁴

The foot height of Bangalee and Chakma females of Bangladesh were 6.38 ± 0.55 cm and 6.32 ± 0.39 cm respectively. The difference was not statistically significant ($p = 0.2282$). Similarity in height and lifestyle may have played a role. The results for Bangalee and Chakma females of Bangladesh were compared with the females of West Bengal and Thailand respectively as they share similar ethnicity. The reported foot height were 6.77 ± 0.56 cm for left foot and 6.87 ± 0.53 cm for right foot in the females of West Bengal.¹⁵ The foot height of the Thai females were 7.75 ± 0.53 cm for right foot and 7.75 ± 0.55 cm for the left foot.¹⁶ Both Bangladeshi groups showed lower value for this variable than the corresponding ethnic groups. Differences in age group, height, climate and lifestyle of the participants of the studies may have been the contributing factor despite their similar ethnicity. Each of those factors are known to have an effect on foot structure.¹⁷⁻¹⁹

The foot length and breadth of Bangalee females were 22.91 ± 0.79 cm and 8.55 ± 0.40 cm respectively. The foot length and breadth Chakma females were 23.11 ± 0.78 cm and 9.22 ± 0.48 cm respectively. The results for foot length and breadth in the Bangalee females of Bangladeshi origin are in accordance with those of the females of West Bengal. Accordingly Chakma and Thai females showed similar results for those variables.^{15,16} These similarities among those ethnic groups could be due to genetic factor.

Yoruba women of Nigeria had higher mean values for foot height (6.76 ± 0.81 cm) breadth (9.35 ± 0.58 cm) and length (24.77 ± 0.98 cm) than the Bangalee and Chakma females.⁹ In the present study, Chakma females showed longer and broader feet than the Bangalees. Apart from ethnic factor, dwelling in warmer climate may have contributed to the larger dimensions of foot in Yoruba and Chakma females. Increased surface area is indicative of genetic adaptation to temperature stress which facilitates heat dissipation.²⁰ Therefore, longer and broader appendages of Chakma females may have been the result of adaptation to relatively warmer climate.

Populations of similar ethnic origin also show structural variations in foot, which is apparent in the existence of variations within Mongoloid and Indian groups.^{15,16,19,21} East Asian populations including Japanese have a smaller foot length for height compared to Southeast Asians such as Thai and Chakma females though both are of Mongoloid extract. Usage of footwear and environmental factors may cause this variation within the similar ethnic groups. Habitually shod subjects are found to differ strongly from minimally shod and bare-foot populations in foot shape.^{19,22} These variations can also be explained by different authors employing different inclusion criteria, measurement methods and instruments.

Limitations

- As this was a cross-sectional study, causal relationships could not be determined. A longitudinal study is required for that purpose.
- No concrete tests were done to exclude genetic disorders. Instead history of the patients and physical examinations were relied upon for that matter.

Conclusion

The Bangalee and Chakma females differ in terms of their foot structures. Foot structure shows variations within ethnic groups as well as between them. Therefore, it is of great importance to identify the variation and distribution of foot morphological characteristics in different ethnic groups which are essential for the successful design of commercial products such as footwear, prosthetics and orthotics. These information are also necessary to establish an individual's ethnic identity in forensic investigations.

Recommendations

The variables used in this study may not fully represent structural differences that exist between the feet of Bangalee and Chakma women. Future studies should include more variables and possibly other ethnic groups of Bangladesh.

Acknowledgement

The authors would like to thank Professor Dr. Shaikhul Islam (Head, Department of Anatomy of Marine City Medical College, Chattogram) for his valuable advice.

Contribution of authors

SB-Conception, design, acquisition of data, script writing & final approval.

MA-Interpretation of data, critical revision of content & final approval.

LR-Data analysis, critical revision of content & final approval.

Disclosure

The authors declared no competing interests.

References

- Bob-Manuel I, Didia B. Sexual dimorphism in foot dimensions among adult Nigerians. *The Internet Journal of Biological Anthropology*. 2008; 3(1):1-6.
- Mehta M, Saini V, Nath S, Patel MN, Menon SK. CT scan images to determine the origin from craniofacial indices for Gujarati population. *Journal of Forensic Radiology and Imaging*. 2014; 2(2): 64-71.
- Rawangwong S, Chatthong J, Boonchouytan W. Foot anthropometry of primary school children in the south of thailand. *World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*. 2011; 5(12):1928-1933.
- RobRoy L, Martin PT. The Ankle and Foot Complex. In: Levangie, P.K., Norkin, C.C. (eds.) *Joint structure and function: A comprehensive analysis*. 5th ed. F. A. Davis Company, Philadelphia. 2011; 440-481.
- Wunderlich RE, Cavanagh PR. Gender differences in adult foot shape: Implications for shoe design. *Medicine and Science in Sports and Exercise*. 2001; 33(4):605-611.
- Telfer S, Woodburn J. The use of 3D surface scanning for the measurement and assessment of the human foot. *Journal of foot and ankle research*. 2010; 3(1): 1-9.
- Wikipedia 2017, Demographics of Bangladesh. Available at: https://en.wikipedia.org/wiki/Demographics_of_Bangladesh#Ethnic_groups (Accessed: 19th April 2019).
- Wikipedia 2017, Chakma people. Available at: https://en.wikipedia.org/wiki/Chakma_people#cite_note-1 (Accessed: 14th May, 2019).
- Chiroma SM, Attah MO, Taiwo IO, Buba HS, Dibal NI, Jacks TW. Metric analysis of the foot of Yoruba students of Maiduguri, Nigeria. *IOSR Journal of Dental and Medical Sciences*. 2015; 14(8): 63-67.
- Parham KR, Gordon CC, Bensek CK. Anthropometry of the foot and lower leg of U.S. army soldiers Fort Jackson, SC –1985. United States Army Natick Research, Development and Engineering Center Natick. 1992;1-332.
- Emanovsky PD. Intrinsic variability and scaling of the modern human foot: Sexual dimorphism, ecogeographical patterning and biomechanical perspectives. PhD Thesis. University of Florida. 2010;1-188.
- Golightly YM, Hannan MT, Dufour AB and Jordan JM. Racial Differences in Foot Disorders and Foot Type. *Arthritis Care & Research*. 2012; 64(11):1756-1759.
- Hills AP, Henning EM, McDonald M and Bar-Or O. Plantar pressure differences between obese and non-obese adults: A biomechanical analysis. *International journal of obesity and related metabolic disorders: Journal of the International Association for the Study of Obesity*. 2001; 25(11):1674-1679.
- WORLD HEALTH ORGANIZATION. body-mass-index-BMI 2017. Available at: <http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi> (Accessed: 20th April 2019).
- Manna I, Pradhan D, Ghosh S, Kar SM, Dhara P. A comparative study of foot dimension between adult male and female and evaluation of foot hazards due to using of footwear. *Journal of Physiological Anthropology and Applied Human Science*. 2001; 20(4): 241-246.
- Suakabkaew T, Ricngrojpitak S, Tiensuwar M. Stature Estimation from Foot Measurements in Thais. *Proceedings of the Anatomy Association of Thailand*. 2012;74-77.
- Tomassoni D, Traini E, Amenta F. Gender and age related differences in foot morphology. *Maturitas*. 2014; 79:421-427.
- Jervas E. Foot Anthropometry: A Forensic and Prosthetic Application. *International Journal of Science and Research*. 2015; 4(6): 738-746.
- Kouchi M. Foot dimensions and foot shape: Differences due to growth, generation and ethnic origin. *Anthropological Science*. 1998; 106(Supplement):161-188.
- Katzmarzyk PT, Leonard WR. Climatic influences on human body size and proportions: Ecological adaptations and secular trends. *American Journal of Physical Anthropology*. 1998; 106(4):483-503.
- Srivastava A and Yadav VK. Reconstruction of stature using hand and foot dimensions among Indian population. *International Journal of Engineering Sciences & Emerging Technologies*. 2014; 6(4): 400-404.
- D'Aou t K, Patakyc TC, De Clercq D, Aertsad P. The effects of habitual footwear use: Foot shape and function in native barefoot walkers. *Footwear Science*. 2009; 1(2):81-94.