Journal of Chitwan Medical College 2020;10(33):39-42
Available online at: www.jcmc.com.np

ORIGINAL RESEARCH ARTICLE

FOOT INDEX: IS IT A TOOL FOR GENDER DETERMINATION AMONG NEPALESE POPULATION?

Dil Islam Mansur[1,*], Raj Kumar Karki[2], Pragya Shrestha[1], Dilip Kumar Mehta[1], Sunima Maskey[1], Shreya Dahal[1]
[1]Department of Anatomy, Kathmandu University School of Medical Sciences, Dhulikhel, Nepal
[2]Department of Forensic Medicine, Kathmandu University School of Medical Sciences, Dhulikhel, Nepal

Received: 27 May, 2020
Accepted: 11 Sept, 2020
Published: 27 Sept, 2020

Key words: Age groups; Foot; Gender identity; Population

***Correspondence to:** Dil Islam Mansur, Department of Anatomy, Kathmandu University School of Medical Sciences, Dhulikhel, Nepal.*
Email: dilislam@kusms.edu.np

Citation

Mansur DI, Karki RK, Mehta DK, Maskey S, Dahal S. Foot index: is it a tool for gender determination among Nepalese population?. Journal of Chitwan Medical College.2020;10(33):39-42.

ABSTRACT

Background: The human foot shows variations in its dimensions and shape in different age group of both male and female. It can be used as gender predictor of an individual in forensic science investigations which may have a great value for identification of unknown deceased body. This study was aimed to measure the various dimensions of foot and derive a tool to predict gender of an individual.

Methods: This study was the cross-sectional type which consisted of 556 individuals (268 males and 288 females). Foot dimensions (foot length and foot breadth) were measured in centimeter and the foot index was derived for both sexes separately. The data was analyzed using descriptive statistics with SPSS vesion 20.0.

Results: It was concluded that there were gender differences in foot length and breadth. The foot length and foot breadth were found to be higher among males than females. The bilateral differences of foot dimensions were not recorded in both male and female. There were gender differences in foot index.

Conclusions: The male is found having longer and broader foot than female foot. The foot index is not used as an appropriate tool to determine gender.

INTRODUCTION

The human foot is a complex structure adapted to allow bipedal locomotion which is the only part of the body that is in regular contact with the ground.[1] It plays an important role in body weight support and shock absorption as well as providing balance and stabilization of the body during gait.[2] Its morphology varies considerably due to the combined effects of heredity, lifestyle and climatic factors.[3] The natural biological variances such as age, sex and ethnicity have also significant influences on the morphology of an individual's foot.[4]

In recent years, there are increased numbers of natural disasters (earthquake, flood, landslide and tsunami), road traffic accidents, air crashes and train accidents in which it is common to pick out numerous dismembered and fragmented human body.[5] Whereas in homicide cases, fragments of body parts are found to be disposed in less visited places.[6] The decomposed condition of the bodies conceals the identity of victims. Thus, identification may become a difficult task.[5]

Generally, identity of a victim is commonly determined through unique body parts.[7] The issue of personal identification from foot is very important as foot is often recovered from the site of mass disasters both natural as well as man made.[8] Male feet are on average longer and broader than female thus the size of foot can be used to determine sex of the individual.[9] Therefore, the aim of this study was to determine whether the foot index is an appropriate tool for gender estimation or not.

METHODS

This was the descriptive and cross-sectional study which was conducted among the students of Kathmandu University School of Medical Sciences, Dhulikhel, Nepal during the period from June 2015 to May 2019. A total of 556 individuals (268 males and 288 females) with age ranging from 18 to 25 years were recruited as subjects. The subjects with apparent foot anomalies, trauma, deformities and surgery (if any) were excluded from the study. Approval from Institutional Review committee was obtained prior to the beginning of the study (Ref. No. 51/14). Convenience sampling was done and the 556 sample size was included in the study.

All the subjects were explained how the study will be conducted. The verbal consent was obtained from each subject for this

study. All the subjects were barefooted at the time of recording the measurements. All the measurements for the study were taken with the subjects standing in the anatomical position. Foot length was measured as the direct distance from the most posterior point of the heel (pternion) to the most anterior point of the longest toe-first or second (acropodion). Foot breadth is defined as the distance between the surfaces of the first and fifth metatarsal bone heads.[10] Foot dimensions (length and breadth) were measured in centimeter using osteometric board and digital caliper (Mitutoyo 500-193 Absolute Digital Caliper, Stainless Steel, Battery Powered, Inch/Metric, 0-12, Japan). The foot index was derived by using a formula: foot index=foot breadth divided by foot length and multiplied by hundred.[11]

All the obtained data were entered into Excel office and statistical analysis was done by using SPSS 20.0.

RESULTS

The mean value for right foot length was found to be 23.25±1.89 cm and left foot length was 23.23±1.88 cm. Similarly, the mean value for right foot breadth was found to be 9.19±1.07 cm and left foot breadth was 9.20±1.07 cm as shown in table 1.

The mean value for foot length was found to be 23.96±2.12 cm and 22.57±1.32 among males and females respectively. Similarly, the mean value for foot breadth was found to be 9.40±1.02 cm and 9.00±1.08 among males and females respectively as shown in table 1. Hence, it was concluded that there were differences between males and females. It was also revealed that foot length and foot breadth were higher in males as compared to females. So, it was concluded that males had slightly longer and wider foot than females.

Table 1: Descriptive statistical analysis of length and breadth of foot

		Right	Left	Males	Females
Length (cm)	Range	18.00-28.50	18.00-28.70	18.00-28.70	19.00-27.00
	Mean±S.D.	23.25±1.89	23.23±1.88	23.96±2.12	22.57±1.32
Breadth (cm)	Range	6.00-12.00	6.00-12.00	7.00-12.00	6.00-12.00
	Mean±S.D.	9.19±1.07	9.20±1.07	9.40±1.02	9.00±1.08

Table 2: Foot index for both males and females

Side	Gender	Foot index
Right Foot	Males	39.21±3.78
	Females	39.86±4.83
Left Foot	Males	39.27±3.79
	Females	39.92±4.83
Combined	Males	39.24±3.78
	Females	39.89±4.82

Table 3: Age wise distribution of foot index in males

Age (year)	Number	Right foot			Left foot		
		Length (cm)	Breadth (cm)	Foot index	Length (cm)	Breadth (cm)	Foot index
18	19	23.38	9.39	40.16	23.40	9.39	40.13
19	76	23.94	9.39	39.22	23.94	9.41	39.31
20	86	23.65	9.46	40.00	23.63	9.47	40.07
21	42	24.33	9.23	37.94	24.28	9.24	38.06
22	30	24.54	9.48	38.63	24.53	9.48	38.65
23	7	24.29	9.43	38.82	24.29	9.43	38.82
24	4	25.25	9.83	38.93	25.25	9.83	38.93
25	4	24.85	8.75	35.21	24.25	8.75	36.08

Right foot index was found to be 39.21±3.78 among males and 39.86±4.83 among females. Similarly, left foot index was found to be 39.27±3.79 among males and 39.92±4.83 among females. The mean value for foot index was concluded 39.24±3.78 among males and 39.89±4.82 among females for both right and left feet. The foot index among males was observed smaller than among females as shown in table 2.

Age wise calculation of foot index was also done. In males, the right foot index was found the lowest (35.21) at the age of 25 years and the highest (40.16) at the age of 18 years with the mean value of 38.61 and in females it was also noted the lowest (37.30) at the age of 25 years and the highest (41.15) at the age of 21 years with the mean value of 39.10. Similarly, left foot index was found the lowest (36.08) at the age of 25 years and the highest (40.13) at the age of 18 years with the mean value of 38.76 among males and it was also noted the lowest (37.49) at the age of 25 years and the highest (41.17) at the age of 21 years with the mean value of 39.17 among females as shown

in table 3 and 4.

Though differences between male and female foot were recorded in all age groups (18-25 years), no any fixed deviation point was recorded to determine the genders. Therefore, foot index cannot be taken as a deviation point for gender determination.

Table 4: Age wise distribution of foot index in females

Age (year)	Number	Right foot			Left foot		
		Length (cm)	Breadth (cm)	Foot index	Length (cm)	Breadth (cm)	Foot index
18	38	22.70	8.80	38.77	22.57	8.82	39.20
19	74	22.37	9.10	40.68	22.37	9.10	40.68
20	83	22.62	9.11	40.27	22.60	9.13	40.40
21	36	22.77	9.37	41.15	22.76	9.37	41.17
22	24	22.68	8.72	38.45	22.69	8.68	38.25
23	18	22.68	8.66	38.18	22.87	8.68	37.95
24	11	22.41	8.51	37.97	22.55	8.62	38.23
25	4	21.93	8.18	37.30	21.95	8.23	37.49

DISCUSSION

The human foot is required to be stable for supporting body weight in standing, resilient for walking and accommodating to variations of surface on which it is placed. It shows great individual variation in its dimensions in both males and females.[12] Sexual dimorphism represents a group of morphologic characteristics that differentiate males from females which is evident from fetal life, but emerges primarily during puberty.[13]

Identification of a person plays a vital role during natural disasters, terror strikes, in crime scene and also in our day to day life.[14] It is often required in medico legal practice.[7] Gender is one of the important parameters used in biological profiles as an indicator of identity.[15] Identity of an individual from the foot and its parts is an important in forensic investigation when there is a only recovery of foot (often enclosed in shoes) after mass disasters such as earthquake, plane crashes, bomb blasts and other accidents.[16] In recent years, there is an increased modern technology such as determination of sex with DNA analysis which has simplified forensic investigation. However, several times it cannot fulfils the prospect to identify demolished remains and it cannot also be applied in all the cases as well as regions due to lack of time and infrastructures.[17]

Bilateral symmetry of human foot was noticed among both genders in the present study. A similar study was done in Karnataka, India on adult population and found that there was no bilateral differences in all the foot dimensions in both genders.[18] In contrast, a study on adult Nigerian population claimed that right sided foot was longer and broader than left foot.[19] In a study on Haryanvi jat population, foot length and foot breadth were higher on right side in males whereas these parameters were higher on left side in females.[13] This can be endorsed to obvious difference in genetic makeup of males and females and early maturity of females than males.

In males, it was found that foot length was larger as compared to females thus sexual dimorphism exists on the basis of foot length. Similarly, foot breadth was larger in males as compared to females thus sexual dimorphism exists on the basis of foot dimensions. Earlier studies on sex determination with foot dimension also suggested the similar results that males had statistically larger dimension of foot than females.[13,14] Male-female differences was found for both foot length and foot breadth. Investigators also investigated in other population groups who found similar differences and suggested this could be because of heavier bone structure of the male skeleton causing increased weight bearing on the males foot compared to females.[9,16]

The difference in foot dimensions between males and females could explain as part of genetic expression that males being larger than females, in addition differences in body dimension among population and ethnic origins may be due to differences in nutrition, traditional habits and degree of physical activity.[20] A study also quoted that males were found to be taller than females due to the puberty period. The age of puberty in males is two years later than females which allows them an extra time for body growth.[8] This could probably be due to earlier closure of the epiphysis in females due to the effect of estrogen leading to a smaller overall bone structure.[17,21]

The determination of sex is statistically the most important criteria in identification of individual as it excludes approximately half the population at risk.[22] A study done in Mauritius, reported that foot index can be used as a deviation point for the sex determination, that is in males, foot index value is considered to be less than 37 and in females more than 37.[7] In an another study in North Indian mixed population, Singla et al also found that foot index more than 36 was suggestive of females and less than 36 was males.[23] However, the present study failed to get any fixed deviation point from foot index for sex determination among Nepalese population which is also supported by a recent study done in Nepal.[24] Similar studies were also done in a single community of North India[25] and in Slovak Republic;[26] and revealed that foot index cannot be used to determine gender which is agreement with the present study. This variation may be due to combined effects of heredity and living style as well as genetics and environmental factors.

In the present study, it was also obseved that the foot index was found to be slightly higher among females as compared to males. A similar result was also found in the studies done in Mauritius[7] and North Indian[25] populations. However a study conducted in Nepal and revealed that foot index was found to be significantly higher among males than females.[24] The reason for this difference could be associated to the environmental, genetic and physical factors. The people of Nepal is known to do relatively more physical activities and walking long distances with carrying goods due to geographical structures and shortage of expensive modern transportation machinery besides lack of roads. Owing to such practices and weight bearing habits could be affected their shape and size of foot.[27]

CONCLUSION

This study is able to establish data of the mean value for foot length and foot breadth among males and females separately. It is also concluded that the males have longer and broader foot dimensions than females which may be useful for researchers in their evolutional studies. It may also useful for shoe designers for selection of shoe size for better fit and more comfort.

Though foot dimensions show gender differences, foot index does not exist any reasonable accuracy for sexual dimorphism. Therefore, foot index could not be used as a tool for sex determination amongst the Nepalese population. Further researches are needed in this field in other region of Nepal to add to existing data.

ACKNOWLEDGEMENT

The authors greatly acknowledge the willingness of the students who volunteered to participate in this study despite their busy class schedule.

CONFLICT OF INTEREST: None

FINANCIAL DISCLOSURE: None

REFERENCES:

1. Standring S. Gray's Anatomy, The anatomical basis of clinical practice. 41st edition. In Chap: The Foot and Ankle. Churchill-Livingstone; Elsevier. 2016:1418-51.
2. Deepashini H, Omar B, Paungmali A, Amaramalar N, Ohnmar H, Leonard J. An insight into the plantar pressure distribution of the foot in clinical practice: Narrative review. Polish Ann Med. 2014;21(1):51-6. [DOI]
3. Ukoha UU, Egwu OA, Ezeani MC, Anyabolu AE, Ejimofor OC, Nzeako HC, et al. Estimation of Stature using footprints in an adult student population in Nigeria. Int J Biomed Res. 2013;4(11):827-33. [DOI]
4. Krauss I, Grau S, Mauch M, Maiwald C, Horstmann T. Sex-related differences in foot shape. Ergonomics. 2008;51(11):1693-709. [DOI]
5. Zeybek G, Ergur I, Demiroglu Z. Stature and gender estimation using foot measurements. Forensic Sci Int. 2008;181(1-3):54.e1-5. [DOI]
6. Mant Keith A. Identification of the living and dead. Taylor's Principles and Practice of Medical Jurisprudence. 13th Edition. B.I. Churchill Livingstone Pvt. Ltd, New Delhi. 1995:156-82.
7. Agnihotri AK, Shukla S, Purwar B. Determination of sex from foot measurements. Internet J Forensic Sci. 2006;2(1):1-4. [LINK]
8. Krishan K. Determination of stature from foot and its segments in a North Indian population. Am J Forensic Med Pathol. 2008;29(4):297-303. [DOI]
9. Wunderlich RE, Cavanagh PR. Gender differences in adult foot shape: implications for shoe design. Med Sci Sports Exerc. 2001;33(4):605-11. [PMID]
10. Martin R, Saller K. Lehrbuch der Anthropologie. 3rd edition, Vol. I, Stuttgart, Gustav Fischer 1957:625-43.
11. Klementa J. Somatometrie nohy. Praha: SPN. 1987:232.
12. Snell, Richards. Clinical Anatomy for medical students 6th edition. Lippincott Williams and Wilkins, Philadelphia. 2000;91:591-5.
13. Walia S, Modi BS, Puri N. Sexual dimorphism from foot dimensions and foot prints in haryanvi jat population. Int J Anat Res. 2016;4(1):2142-7. [LINK]
14. Kautilya DV, Bodkha P, Poothanathan P. Determination of stature and sex from anthropometry of the foot among south Indians. Int J Rev Life Sci. 2013;3(2):22-6. [LINK]
15. Mastrangelo P, De Luca S, Alemán I, Botella MC. Sex assessment from the carpals bones: discriminant function analysis in a 20th century Spanish sample. Forensic Sci Int. 2011;206(1-3):216.e1-10. [DOI]
16. Krishan K, Kanchan T, Sharma A. Sex determination from hand and foot dimensions in a North Indian population. J forensic Sci. 2011;56(2):453-9. [DOI]
17. Dey S, Kapoor AK. Sex determination from hand dimensions for forensic identification. Int J Res Med Sci. 2015;3(6):1466-72. [DOI]
18. Bindurani MK, Kavyashree AN, Asha KR, Subhash L. Determination of sex from foot dimensions. Int J Anat Res. 2017;5(4.3):4702-6. [LINK]
19. Bob-Manuel I, Didia B. Sexual dimorphism in foot dimensions among adult Nigerians. Internet J Biol Anthropol. 2008;3(1):1-6. [DOI]
20. Maslen BA, Ackland TR. Radiographic study of skin displacement errors in the foot and ankle during standing. Chin Biomech (Bristol Avon).1994;9(5):291-6. [DOI]
21. Mukta R, Tyagi Vinod KR, Yashoda R, Atul M. Stature estimates from foot dimensions. J Punjab Acad Forensic Med Toxicol. 2011;11(1):26-30. [DOI]
22. Saukko P, Knight B. Knights Forensic pathology, infanticide, still birth and fatal child abuse. 3rd edition, Arnold publisher. 1996:461.
23. Singla R, Bedi M, Biswas M. Sex Estimation from foot anthropometry in Haryanvi Jats and North Indian mixed population. J Punjab Acad Forensic Med Toxicol. 2012;12(1):13-6. [LINK]
24. Gupta VP, Shah AH. Sex determination of Nepalese medical students of NAIHS-COM by using foot index method. Acta Scientific Medical Sciences. 2018;2(2):8-11. [LINK]
25. Moudgil R, Kaur R, Menezes RG, Kanchan T, Garg RK. Foot index: Is it a tool for sex estimation? J Forensic Leg Med. 2008;15(4):223-6. [DOI]
26. Uhrova P, Benus R, Masnicova S, Obertova Z, Kramaroma D, Kyselicova K, et al. Estimation of stature using hand and foot dimensions in Slovak adults. Leg Med (Tokyo). 2015;17(2):92-7. [DOI]
27. Bastien GJ, Willems PA, Schepens B, Heglund NC. The mechanics of head-supported load carriage by Nepalese porters. J Exp Bio. 2016;219(22):3626-34. [DOI]