Original Research Article

SEXUAL DIMORPHISM FROM FOOT DIMENSIONS AND FOOT PRINTS IN HARYANVI JAT POPULATION

Sween Walia *[1], Bhawani Shankar Modi [2], Nidhi Puri [3].

[*1] Assistant Professor, Department of Anatomy, PIMS, Jalandhar, Punjab, India.

[2] Demonstrator, Department of Anatomy, FH Medical College, Tundla, UP, India.

[3] Professor, Department of Anatomy, MMIMSR, Mullana, Ambala, Haryana, India.

ABSTRACT

Introduction: Ascertaining gender from incomplete skeleton decomposing body and print of various body parts is a recurring theme in physical anthropology and forensic medicine. The need for determination of sex from skeletal remains in living and non-living population for genetic, anthropological, odontologic and forensic purposes has been documented by several researchers.

Material and Methods: The study was conducted among the residents of Haryana State, belonging to the Jaat Community. Total 400, apparently healthy subjects were selected. Out of them 200 were females and 200 males.

Conclusion: With all observations, analysis and discussion, the conclusions can be drawn from the present study. Length and breadth of foot and foot prints are higher in males as compared to females, whereas foot index and foot print index are higher in females. Haryanvi Jats have longer and wider foot as compared to Andhraties, Bangalees and other North Indian population.

KEY WORDS: Sexual Dimorphism, Foot Dimensions, Haryanvi, Jats, Physical anthropology.

Address for Correspondence: Dr. Sween Walia, Assistant Professor, Department of Anatomy, PIMS, Jalandhar, Punjab, India. **E-Mail:** sweenwalia@gmail.com

INTRODUCTION

Sexual dimorphism in human body composition is evident from fetal life, but emerges primarily during puberty. Forensic podiatry is one such sub discipline of forensic science to have emerged in the recent past. One of the essential tasks of the forensic podiatrist is to identify human remains from the feet by analyzing foot measurements or foot characteristics of the deceased. Sex is considered as one of the big four parameters in forensic identification besides, race, age, and stature. The foot index, however, cannot be estimated in cases where a part of foot is brought for medico legal

investigations [1,2].

Forensic identification from the foot and its parts is important as there is an increased likelihood of the recovery of feet (often enclosed in shoes), separated from the body, in mass disasters such as high power explosions and bomb blasts, air plane crashes and other high impact transportation accidents. The significance of the human foot and its bones, and foot prints in identification has been successfully reported in the past [3].

Manually collecting foot anthropometric data with direct measurement instrument is a traditional approach. The precision of measurement

tend to be influenced by the measurement instruments. Using footprint to collect foot dimensions can reduce the measurement time and the footprint can be stored for further analysis, such as calculating arch index. Further, with the advancement of optoelectronic technologies, the scanning technique was employed to collect anthropometry data. Using different techniques to collect foot dimensions may lead to inconsistent results [4].

The feet and footprints become extremely significant, especially when a body is incomplete or unavailable. Shoes and shoe prints found in the vicinity of the incidences may also play an important role in the identification of unknown persons [5]. Anthropometry helps in reconstruction of the biological profile of the deceased such as age, sex, Ethnicity and stature. Among these 'big fours' of forensic anthropology, estimation of stature is considered as one of the main parameter of personal identification in forensic examinations [6]. Since database is inadequate in the region the study was designed to evaluate the gender difference in foot and foot print morphometry.

MATERIALS AND METHODS

The study was conducted among the residents of Haryana State, belonging to the Jaat Community. Total 400, apparently healthy subjects were selected. Out of them 200 were females and 200 males. A Population based study design for studying Sexual Dimorphism from Foot Dimensions and Foot Prints In Haryanvi Jaat Population. The subjects of Jaat community of Haryana above the age of 21 years as foot attains maximum growth by this age were included in present study. Subjects with apparent anomalies, inflammation, trauma, deformities and surgery of foot (if any), were excluded in present study. All the measurements for the study have been taken with the subjects standing erect against the wall in anatomical position. Osteometric Board, Scale, Ink Pad, measuring tape, Ink applicator foam, Rubber pad, Plane A4 size paper used as the instruments. After measuring the foot dimensions of every 150 subjects a fresh tape will be used to avoid error.

Foot measurement: Precautions will be taken

by asking the subject to clean the soles by washing with soap and water. After cleaning and drying following foot dimensions will be measured with foot placed horizontally on osteometric board, while the subject will be standing.

Somatometric measurements:

Foot length: It is distance measured from acropodian (it is the most forwardly projecting point on the head of the first or second toe whichever is larger when the subject stands erect) to pternion (it is the most backwardly projecting point on the heel when the subject stands upright with equal pressure on both feet).

Foot breadth: The foot breadth will be measured as the distance between medial margin of the head of the first metatarsal and lateral margin of the fifth metatarsal. The left and right foot measurements will be recorded one by one.

Foot Index = Foot breadth / Foot length x 100.

Foot print measurement:

After measurement of foot was taken subject will be asked to sit comfortably, cyclostyling ink will be applied to the cleaned soles of the subjects using the applicator; the ink will be applied to the entire sole including the toes. Subject is asked to stand erect and step on to white plain paper on flat surface and press the paper first with the heel followed by the sole. The left and right footprints will be recorded one by one.

The use of a foam rubber pad enhances the quality of the print by improving the contact between the paper and all areas of the sole.

Foot print length:

It is distance measured from acropodian (It is the most forwardly projecting point on the head of the first or second toe whichever is larger when the subject stand erect) to pternion (It is the most backwardly projecting point on the heel when the subject stands up right with equal pressure on both feet).

Foot print breadth: The foot print breadth will be measured as the distance between medial margin of the head of the first metatarsal print and lateral margin of the fifth metatarsal print.

Foot print index: Foot print breadth / Foot print length x 100.

RESULTS AND OBSERVATIONS

In the present study data on foot and foot print anthropometry of 400 adults of Haryanvi Jat community (200 of either sex) with the age of 21 to 25 years was collected. Observations are as follows:

Table 1: Comparisons between left foot dimension and foot print dimension of total subjects.

Variable	Dimension	N	Mean	SD	SEM	p Value
Foot length	Print	400	23.41	1.48	0.07	0.0001*
	Foot	400	24.91	1.65	0.08	
Foot breadth	Print	400	8.97	0.66	0.03	0.0001*
	Foot	400	9.69	0.7	0.04	
Foot index	Print	400	38.32	2	0.1	0.0001*
	Foot	400	38.91	7.87	0.09	

*p value < 0.005 have been considered to be statistically highly significant.

Table 2: Male: comparison between foot dimension and foot print dimension of right.

Variable	Dimension	N	Mean	SD	Min.	Max.	p Value
Foot length	Print	200	24.41	1.17	21.4	27.8	0.0001*
	Foot	200	26.17	1.15	23.1	29.6	
Foot breadth	Print	200	9.31	0.53	7.5	10.7	0.0001*
	Foot	200	10.15	0.53	8.3	11.5	
Foot index	Print	200	38.19	1.97	33.1	44.6	0.0012*
	Foot	200	38.8	1.81	33.9	44.6	

*p value < 0.005 have been considered to be statistically highly significant.

Table 3: Comparisons of right foot dimensions between male and female.

Variables	Sex	N	Mean	SD	Min.	Max.	p value
Foot Length	Male	200	26.17	1.15	23.1	29.6	0.000*
	Female	200	23.47	1.01	20.3	25.7	
Foot Breadth	Male	200	10.15	0.53	8.3	11.5	0.000*
	Female	200	9.14	0.54	8.1	10.7	
Foot Index	Male	200	38.8	1.81	33.9	44.6	0.483
	Female	200	38.94	2.13	33.85	45.91	

*p value < 0.005 have been considered to be statistically highly significant.

Table 4: Regression equation for foot morphometry between male and female.

Variables	Sex	Regression equation	R^2	p Value
Foot Length-Right	Male	$Y = 0.0195 \cdot X + 22.96$	0.0005	0.756
	Female			
Foot Breadth-Right	Male	$Y = -0.0007 \cdot X + 9.142$	4.092	0.993
	Female			
Foot Length-Left	Male	$Y = 0.0656 \cdot X + 21.95$	0.0051	0.315
	Female			
Foot Breadth-Left	Male	$Y = -0.0095 \cdot X + 9.327$	8.878	0.895
	Female			
Foot Index-Right	Male	$Y = 0.0072 \cdot X + 38.66$	3.815	0.931
	Female			
Foot Index-Left	Male	$Y = 0.0562 \cdot X + 36.85$	0.0024	0.494
	Female			

Table 5: Regression equation for foot print morphometry between male and female.

Variables	Sex	Regression equation	R^2	p Value
Foot Print Length-Right	Male	$Y = 0.01065 \cdot X + 22.00$	0.0002	0.862
	Female			
Foot Print Breadth-Right	Male	$Y = 0.0095 \cdot X + 8.436$	7.793	0.901
	Female			
Foot Print Length-Left	Male	$Y = 0.0624 \cdot X + 20.89$	0.0047	0.336
	Female			
Foot Print Breadth-Left	Male	$Y = -0.0334 \cdot X + 8.912$	0.0011	0.646
	Female			
Foot Print Index-Right	Male	$Y = 0.0089 \cdot X + 37.97$	5.762	0.915
	Female			
Foot Print Index-Left	Male	$Y = 0.0008 \cdot X + 38.35$	4.469	0.993
	Female			

Table 5, shows the regression equation of foot print morphometry between male and female. In this equation it was concluded that foot length of female (y) is dependent variable and foot length of male (x) is independent. R^2 and p values shows that there is no statistically correlation between foot morphometry of male and female.

DISCUSSION

The human foot is a highly complex structure, with 26 major bones and more than 30 synovial joints. It plays a role in both load support and shock absorption during walking [7]. The human foot exhibits a wide range of structural variations than many other parts of the body. During growth, the foot changes not only its dimensions but also its shape. The human foot, the foundation for bipedal locomotion, is a complex adaptation that evolved through

extensive remodeling of the hind appendage of the human arboreal primate forebears.

The characteristics of foot shape are manifold, since numerous factors are associated with foot morphology. Aside from natural biological variance, distinctive age classes and population groups show prevalent qualities in foot dimensions. The foot is the base of support for the chain of motion and body posture, foot length also affects dorsoventral stability.

Table 6: Studies having lower results of foot dimensions as compared to the present study.

Study	Study group	Age group	Sex	Total subjects	Mean foot length ± SD	p value with present study
Present Study	Haryanvi Jat	21-25 yrs	M	200	26.16 ± 1.13	
			F	200	23.57 ± 1.02	
Ilayperuma et al [14]	Sri- Lanka	20-23	M	140	25.37± 1.05	0.0001*
			F	118	23.33±1.05	0.05*
Agnihotri et al. [10]	SSR Medical College, Mauritius	18+	M	125	26.16 ± 1.06	1
			F	125	23.31 ± 1.07	0.03*
Goonetilleke RS et al. [9]	Hong-Kong, Chinese	20-25	M	31	25.2±1.08	0.004*
			F	NA	NA	
Bhavna, Nath et al. [12]	Shia Muslims, Delhi	20-40	M	503	24.88±1.61	0.0001*
			F	NA	NA	
Krishan K. [4]	North India	17-20	M	123	24.7±1.2	0.0001*
			F	123	22.6±1.1	0.0001*
Krishan K. et al. [6]	Turkey	17-83	M	253	25.84±1.26	0.005*
			F	253	23.43±1.07	0.16
Sherk et al. [15]	Narketpally, AP	17-22	M	150	26.0±1.24	0.21
			F	150	23.7±1.03	0.24
Kanaani JM et al. [8]	Iranian	18-25	M	160	24.67±1.23	0.0001*
			F	NA	NA	

Table 7: Comparison of foot index between the present study and various studies.

Study	Study group	Age group	Sex	Total subjects	Mean right foot index ± SD	Mean left foot index ± SD
Danborno B, Elukpo A. [18]	AB University, Nigeria	24.5	M	250	34.17±2.67	34.28±2.44
		22.22	F	150	33.65±2.19	32.60±2.35
Ibinabo et al. [11]	Port Harcourt	18+	M	249	36.67±1.95	36.51±1.97
			F	228	36.55±2.25	36.09±2.27
AK Agnihotri et al. [10]	SSR Medical College, Mauritius	18+	M	125	36.50-36.97	
			F	125	37.04-37.93	
Singla et al. [13]	Haryanvi Jat	18-50	M	150	36.93±1.93	36.83±2.14
			F	150	37.06±2.44	37.09±2.35
Singla et al. [13]	North Indian Mixed Population	18-50	M	150	34.55±3.0	34.41±2.98
			F	150	36.54±2.99	36.88±1.90
Present Study	Haryanvi Jat	21-25	M	200	38.8±1.81	38.79±1.73
			F	200	38.94±2.13	39.03±2

Foot length in present study was significantly higher in Haryanvi Jat males (Table 6). Results of present study regarding sexual dimorphism in foot length are similar to many studies (Table 6.and 7). In present study foot length in both sexes was higher in comparison to the studies done in Mauritius, Turkey and South India whereas statistically higher as compared to studies done in Sri Lanka, North India and Iran (Table 6). Decreased foot length in Mauritius,

North India, Turkey, Iran and South Indian studies could be due to the fact that their studies have included subjects below 20 years but the epiphysal fusion at base of first metatarsal and head of second metatarsal completes by 20 years and there are chances of increase in foot length up to 20 years. As height and foot length are proportionately correlated, average height of Sri Lankans has been reported to be less than that of Indians, which could explain their lesser foot length in comparison to present study [1]. In the study from China the number of subjects included is very less, hence data cannot considered as representative of the population.

In the present study, males had an average foot length about 2.59cm greater than the female foot length. The foot breadth was about 0.9cm greater in males as compared to females, and the foot index in females was found to be significantly higher as compared to male. Similar result was found in the studies done in Mauritius, another study of Haryanvi Jats and North Indian populations. However studies done in Nigeria were found higher value of foot index in males which is not in agreement with this study. A study done in Mauritius [10], 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. Whereas in the data of present study foot index values for both genders was found to be higher than 37, thus this statement is not agreeable. An another study done on Haryanvi Jat population [13] reported lower foot index values as compared to present study, which could be due to the less foot length and breadth, and reason for which has been explained earlier.

In present study, male foot length as well as foot breadth was found to be higher on right side. Similar data was found in studies done on population of Haryana, Rohtak, Bengal, Mauritius and Nigeria. Whereas another studies done on Slovakia, Turkish and Nigerian population found higher foot dimensions on left side which is not similar to the present study.

In female foot length and foot breadth was found to be higher on left side. Similar data was found in studies done on Slovakian, Haryanvi Jats,

North Indians and Turkish population. Whereas contradictory results were found in another study done on turkish population and similarly on populations of Bengal, Mangalore, and Nigeria. The reason for this difference could be because of variation in community and environmental factors.

CONCLUSION

With all observations, analysis and discussion, the conclusions can be drawn from the present study.Length and breadth of foot and foot prints are higher in males as compared to females, whereas foot index and foot print index are higher in females. Haryanvi Jats have longer and wider foot as compared to Andhraties, Bangalees and other North Indian population. Populations of Sri Lanka, Mauritius, China, Turkey and Iran have smaller foot parameters as compared to Haryanvi Jats. Haryanvi Jats have smaller foot parameters from people belonging to Nigeria, United State (Army Persons), Croatians and Australians. Foot prints length and breadth are less in comparison to foot morphometry. Our study provides the baseline data for the Haryanvi Jat community thus fulfilling the aim of this study.

Conflicts of Interests: None

REFERENCES

[1]. Agnihotri AK, Lalloo AKS. Estimation of stature from fragmented human remains. Anthropol 2013;1(2):105-6.

[2]. Krishan K, Kanchan T, Passi N, DiMaggio JA. Heel–Ball (HB) Index: sexual dimorphism of a new index from foot dimensions. J Forensic Sci. 2012;57(1):172-5.

[3]. Krishan K, Kanchan T, Passi N. Estimation of stature from the foot and its segments in a sub-adult female population of North India. J Foot Ankle Res.2011;4(1):24-31.

[4]. Krishan K. Estimation of stature from footprint and foot outline dimensions in Gujjars of North India. Forensic Science International 2008;175:93-101.

[5]. Atamturk D. Estimation of sex from the dimensions of foot, footprints, and shoe. Anthrop. Anz. 2010;68(1):21–9.

[6]. Krishan K, Kanchan T, Sharma A. Multiplication factor versus regression analysis in stature estimation from hand and foot dimensions. J Forensic and Legal Medicine.2012; 19:211-14.

[7]. Tsung BYS, Zhang M, Fan YB, Boone DA. Quantitative comparison of plantar foot shapes under different weight-bearing conditions. J Rehabil Res Dev. 2003;40(6):517-26.

[8]. Kanaani JM, Mortazavi SB, Khavanin A, Mirzai R, Rasulzadeh Y, Mansurizadeh M. Foot anthropometry of 18-25 years old Iranian male students. Asian Journal of Scientific Research. 2010;3(1):62-9.

[9]. Goonetilleke RS, Fan Ho EC, Richard HYS. Foot anthropometry in Hong Kong. Available From: http://ihome.ust.hk/~imhcf/papers/aseanfoo.pdf [Accessed on 2014-03-07]

[10]. Agnihotri AK, Shukla S, Purwar B. Determination of sex from foot measurements. Internet J Forensic Sci 2007; 2(1). DOI:10.5580/1283.

[11] Bob-Manuel IFD, Didia BC. Sexual dimorphism in foot dimensions among adult Nigerians. Internet J Biol Anthropol 2009;3(1). DOI: 10.5580/2e5.

[12]. Bhavna, Nath S. Estimation of stature on the basis of measurements of the lower limb. Anthropologist special. 2007;(3):219-22.

[13]. 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.

[14]. Ilayperuma I, Nanayakkara BG, Palahepitiya KN. A model for reconstruction of personal stature based on the, measurements of foot length. Galle Medical Journal. 2008;13(1):6-9.

[15]. Sherke AR, Tamgire DW. Correlations of stature with foot length in Andhra region. IJBR.2013;04(09):494-98.

[16].Ranasinghe P, Naveen MA, Jayawardana AAD, Godwin R, Rezvi MH, David RM et al. Patterns and correlates of adult height in Sri Lanka. Economics and Human Biology.2011;9:23–9.

[17]. Soames RW. Skeltal System. In: Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, Ferguson MWJ, editors. Gray's Anatomy. 38th ed. London. Churchill Livingston;1999.

[18]. Danborno B, Elukpo A. Sexual dimorphism in hand and foot length, indices, stature-ratio and relationship to height in Nigerians. The Internet Journal of Forensic Science. 2008;3(1):379-83.

How to cite this article:

Sween Walia, Bhawani Shankar Modi, Nidhi Puri. SEXUAL DIMORPHISM FROM FOOT DIMENSIONS AND FOOT PRINTS IN HARYANVI JAT POPULATION. Int J Anat Res 2016;4(1):2142-2147. **DOI:** 10.16965/ijar.2016.165