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RESEARCH ARTICLE

A COMPARATIVE ANALYSIS OF FOOT ANTHROPOMETRY IN ADULT MALE POPULATION OF HARYANA, INDIA.

Thakyal Sanjeev[1], Khanna Munish[2] and Rustagi SM[3].

1. Assistant Professor Department of Anatomy Pt JLNGMC&H Chamba HP
2. Associate Professor Department of Anatomy Pt JLNGMC&H Chamba HP.
3. Associate Professor Department of Anatomy VMMC &H, Delhi.

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Abstract

The present study was aimed at measuring foot indices of 150 male subjects and thereby providing a baseline anthropometric data that is of significance in forensic science, orthopedics and other allied health sciences. The study was carried out on male subjects 18years and above. Footedness was analyzed by using the criterion, like kicking the ball or preference of the subject to use a particular foot while initiating walking. Of the subjects analyzed, majority of them were found to be right footed.

Introduction:-

Each of the human foot is a highly complex structure with 26 major bones and more than 30 synovial articulations[1]. These articulations are supported by ligaments, tendons and intrinsic muscles of the foot. This complex anatomy of the foot is meant to sub serve the primary function of the foot which is mobility or locomotion. While both our feet are structurally same, functionally, they are slightly different. It has been observed that there is a natural inherent tendency to use one of the foot more often than the other and this foot which is preferably used for the motor activities is the is the preferred foot or the dominant foot and the foot that is used for support the body weight is the non preferred foot[2]. With a complex structure and dynamic function human foot has been subject of various experimental studies. These studies are able to measure, simultaneously both the kinematics and dynamic structural behaviors of the foot during gait[3].

Footedness in human is overwhelmingly right sided[4] and various studies have been done on lateralization encompassing multiple professional and scholarly disciplines such as philosophy, physical and social anthropology, medical genetics, biochemistry, evolutionary biology aesthetics and cognitive psychology[5] .

Footedness has been implicated as a risk factor for the development of pathology in that particular limb. This is because most individuals place a greater demand on their preferred foot during various motor activities. Thus long term mechanical stress acting homogenously on the preferred lower limb may cause injuries and hazards to that limb.

Materials & Methods:-

The present study was conducted in department of anatomy at M.M.I.M.S.R Mullana, Ambala on 150 males students of 18yrs and above.The subjects were chosen on simple random basis from among the medical students at M.M.I.M.S.R Mullana, Ambala.

Prior informed consent was for the study was obtained in English and vernacular language. `

Inclusion criterion:- following population was included in the study
1. Only those who were willing to participate were included
2. Subjects above 18yers of age
3. Subjects were drawn from amongst the students of M.M.I.M.S.R Mullana, Ambala

Exclusion criterion:-
1. Subjects with apparent physical foot anomalies, inflammation, trauma, deformities and surgery (if any) were excluded.
2. Subjects below 18yrs of age were excluded
3. Subjects other than medical students of MMIMSR, Ambala.

The arithmetic mean of all the foot parameters of 150 males medical students were statistically analyzed using students t-test.The right and left feet of right and left footed subjects were analyzed statistically using student t-test, tabulated and co-related with each other.

Ethical Justification:-
Only those subjects who volunteered to participate in the study after informed consent were taken and the data was kept confidential. Study did not cause any financial burden on the subjects or the institute; therefore the study is ethically justified.

Observations:-

Present study was conducted on 150 males. Foot anthropometric measurements and footedness of each foot of the subject were measured and checked by using the criteria given. Mean age of subjects in the study was 19.14years. The measurements and comparison of results for the right and left feet of right and left footed males who participated in the study were done as per following details

Measurements and indices :-The following indices were measured for the 150 male subjects:
1. Foot length, measured between acropodian* and pternion**
2. Foot breadth, measured between medial and lateral margin
3. Foot height, distance from floor to the pheasant***
4. Foot index:Foot breadth/Foot length x 100

Foot Height:-
The average right foot height(Shaifaly et al[6,7]) was found to be 7.04±0.75cm (Table 1.1) and that of left foot was 7.20±0.73cm. The left foot height was found to be significantly more than that of right foot height (p=0.002).

Table 1.1:- Mean foot parameters of 150 male students

Parameter (cm)	Right foot[#] Mean±SD	Left foot Mean±SD	p-value
Foot height(FH)	7.04±0.75	7.20±0.73	0.002
Foot breadth(FB)	9.24±0.57	9.54±0.54	0.120
Foot length(FL)	25.86±1.33	26.05±1.50	0.007
Foot index(FI) (FB/FBX100)	36.76±1.92[#]	36.68±2.03	0.590

* Shaifaly et al[6,7]

*Acropodian: most forwardly projecting point on the head of 1st or 2nd toe
**Pternion: most backwardly projecting point on heel
***Pheasant: point where top of the foot meets the front of the leg

Foot Breadth:-
The average right foot breadth (Shaifaly et al[6,7])was found to be 9.49±0.57cm and average left foot breadth 9.54±0.54. The left foot breadth was found to be more than that of right foot breadth and results was statistically not significant.

Foot length:-
Theaverage right foot length(Shaifaly et al[6,7]) was observed to be 25.86±1.33 and that of left foot length was 26.05±1.5cm. The left foot length was found to be significantly more than that of right foot length(p=0.007).

Foot Index:-
The total average foot index of right foot was 36.76±1.92*(Shaifaly et al[6,7]) and that of left foot was 36.68±2.03. The average right foot index was found to be more than that of average left foot index. But the values were not significant (p>0.005).

Footedness or the foot preference:-

Majority of the subjects, 140 males out of total 150 subjects were found to be right footed (93.33%). The remaining 10 males (6.67%) preferred their left foot to kick the ball.

Foot indices in Left footed subjects:-
The following were foot indices in left footed male subjects (Table 1.2):

Table 1.2:- Mean foot parameters in left footed males (N=10)

Parameter (cm)	Right foot Mean±SD	Left foot Mean±SD	p-value
Foot height (FH)	6.60±0.74	6.83±0.58	0.260
Foot breadth (FB)	9.67±0.86	9.73±0.73	0.673
Foot length (FL)	25.80±1.33	26.03±1.11	0.172
Foot index (FI) (FB/FLx100)	37.49±2.88	37.38±2.41	0.874

Foot height:-
In left footed males, the average right foot height was found to be 6.60±0.74cm and that of left foot height was 6.83±0.58cm. The mean left foot height was found to be more than that of mean right foot height. But no significant differences was observed in the foot height.

Foot breadth:-
In left footed males, the average right foot breadth was found to be 9.67±0.86cm and average left foot breadth was 9.73±0.73cm. The left foot breadth was found to be more than that of right foot breadth. No significant difference was observed in the two measurements.

Foot length:-
In left footed males, the average right foot length was observed to be 25.80±1.33cm and that of left foot was 26.03±1.11cm. The left foot length was found to be more than that of right foot length. No significant difference was observed.

Foot index:-
In left footed males, the average right foot index of left footed males was 37.49±2.88 and that of left foot was 37.38±2.11.

Foot indices in Right footed subjects:-
The following were foot indices in right footed subjects (Table 1.3):

Table 1.3:- Mean foot parameters in right footed males(N=140; Shaifaly et al[6,7]).

Parameters (cm)	Right Foot Mean±SD	Left foot Mean±SD	p-value
Foot height (FH)	7.07±0.75	7.22±0.73	0.004
Foot breadth (FB)	9.48±0.55	9.53±0.53	0.138
Foot length	25.68±1.33	26.06±1.53	0.012

(FL)			
Foot Index (FI) (FB/FLX100)	36.70±1.84	36.63±2.00	0.610

Foot height:-

The average foot height was found to be 7.07±0.75cm and that of left foot height was 7.22±0.73cm. The left foot height was found to be significantly more than that of right foot height (p=0.004).

Foot breadth:-

The average right foot breadth was found to be 9.48±0.55cm and average left foot breadth was 9.53cm±0.53cm. No significant difference was observed in foot breadth.

Foot length:-

The average right foot length was observed to be 25.86±1.33cm and that of left foot was 26.06±1.53cm. The left foot length was found to be significantly more than that of right foot length (p==0.012).

Foot Index:-

The average foot index of right foot was 36.70±1.84 and that of left foot was 36.63±2.00. The average right foot index was found to be more than average left foot index. But the difference was not significant.

Discussion:-

The foot dimensions vary between populations and can be attributed to factors such as genetics, environment and social conditions.

In the present study, with regards to the bilateral differences, foot length on left side is significantly longer (Table 2.1). In coincidence with our study, JaydipSenet al[19] and Mukta rani et al[20] also observed significantly longer feet on left side in males. Our similar findings could be due to similar population studied (sub groups of Indian population) and similar sample sizes. However, Barnabas et al[13], Oladipo et al[18] and Agnihotri et al[12] have found longer feet on right side in males. These differences could be due to different geographical population studied. Barnabas et al[13] and Oladipo et al[18] conducted their study on Nigerians whereas Agnihotri et al[12] studied the Mauritian population. In variance to the studies mentioned Mannual Bob et al[14] have found mean foot length to be almost equal on both the right and left side.

Table 2.1:- Comparison of mean Foot length of males of present study group with previous study

Author	Population	No.	Foot length (Mean ±SD)		p-value
			Right Foot	Left Foot	
Present study	Male Medical students	150	25.86±1.33	26.05±1.50	P<0.005
KewalKrishan et al[10]	Himachal Pradesh	123	24.72±1.19	24.70±1.1	p>0.005
JaydipSen et al[19]	Bengalee (Rajbanshi)	175	23.95±1.10	24.01±1.10	p<0.001
Mukta Rani et al[20]	Students of Delhi college	150	23.24±1.58	23.46±1.59	
Oladipo et al[18]	Nigerians	66	25.12±0.51	25.08±0.35	p<0.05
Agnihotri et al[12]	Mauritius	125	26.17±1.05	26.14±1.06	
Manuel Bob et al[15]	Nigerians	249	26.92±1.02	26.92±0.13	
Barnabas and Elukpo[13]	Nigerians	250	28.39±1.73	26.42±1.60	p>0.05
Ozden H el al[9]	Turkey	294	26.00±1.34	26.04±1.36	

However, Mauritian males have longer feet than males of our study. In present study values were less than the Nigerians (Barnabas et al[13] and Manuel Bob et al[15]), and Turkey population (Ozden et al[9]).

Agie at al[3] documented longer feet than our study but they conducted their research on Croatian males and they did not consider bilateral differences. But in contrast, Patel SM et al[11] in his study on Gujrati population has observed smaller feet (mean 24.44cm)in males The longest feet reported in all studies in available literature belong to those studied by Barnabas et al[13] . They have studied the Nigerain population and this racial difference could be the reason for the increased dimension observed.

Table2.2:-Comparision of mean foot breadth of males present study group with previous studies.

Author	Population	Gender	No.	Foot breadth (Mean ±SD)		p-value
				Right Foot	Left Foot	
Present study	Medical students	M	150	9.49±0.57	9.54±0.54	P>0.005
KewalKrishan et al[10]	Himachal Pradesh	M	123	9.52±0.61	9.5±0.61	p>0.005
KewalKrishan et al[14]	Noth Indian Gujjars	M	1040	9.26±2.10	8.91±2.06	
JaydipSen et. al[19]	Bengalee (Rajbanshi)	M	175	9.89±0.50	9.90±0.50	p<0.001
Mukta Rani et. al[20]	Students of Delhi college	M	150	8.52±0.67	8.66±0.68	
Oladipo et al[18]	Nigerians	M	66	9.25±0.28	9.13±0.31	p<0.05
Agnihotri et al[12]	Mauritius	M	125	9.63±0.54	9.62±0.54	
Manuel Bob et al[15]	Nigerians	M	249	9.87±0.53	9.87±0.53	
Barnabas and Elukpo[13]	Nigerians	M	250	9.02±0.72	9.09±0.94	p>0.05
Ozden H el al[9]	Turkey	M	294	9.41±0.99	9.41±0.99	

According to Table 2.2 on comparing present study with previous studies, the feet of the 300 medical students considered in our study are more wide than the feet of Delhi population(Mukta Rani et al[20]), north Indian Gujjars(Kewal Krishan[14]), Nigerains (Oladipo et al[18] and Barbanas et al) and Turkish population(Ozden H et al[9]). In present study, values were less than the north Indian Himachal population (Kewal Krishan[10]), RajbhanshiBangalee population (JaydipSen et al[19]), Mauritius population (Agnihiotri et al[12]), Nigerians (Manuel Bob et al[15]). Nigerians (Oladipoet al[18]) males have less wider feet than the present study males

Table 2.3:- Comparison of Mean foot height of males of present study group with previous studies

Author	Population	Gender	No.	Foot height (Mean ±SD)		p-value
				Right Foot	Left Foot	
Present study	Medical students	M	150	9.49±0.57	9.54±0.54	P>0.005
Manna et al[8]	Bengalese	M	200	8.00±0.81	7.96±0.84	p>0.05
Kanani et al[16]	Iranian	M	160	8.22±0.55		
Bari et al[17]	Malaysian	M	129	5.52±0.70	5.87±0.69	

In males, left feet are significantly higher than right sided feet, however; Manna et al[8] (Bangalese) have found mean right feet height more than the left in males . Our findings are in accordance with Bari et al[17] (Malaysians) where mean left feet height is higher in males (Table 2.3). The difference as compared to our study could be due to the fact that they have studied 5 to 6yr old Malaysian children as opposed to the adult group in our study. In variance to our

study, the Iranian males studied Kannani et al (Iranian) have much higher feet. This may be because of racial and genetic factors.

Table 2.4:- Comparison of Mean Foot Index of Males of Present study group with previous studies

Author	Population	Gender	No.	Foot Index (Mean ±SD)		p-value
				Right Foot	Left Foot	
Present study	Medical students	M	150	36.75±1.92	36.68±2.03	P>0.005
JaydipSen et. al[19]	Bengalee (Rajbanshi)	M	175	41.32±1.80	41.30±1.80	
KewalKrishan et al[14]	Himachal Pradesh	M	123	38.89±2.2	38.65±2.10	
Agnihotri et. al[12]	Mauritius	M	125	36.90±0.54	36.91±0.54	
Barnabas and Elukpo[13]	Nigerians	M	250	34.17±2.67	34.28±2.19	P<0.005

Table 2.4 depicts the mean right foot index was found to be more in males as compared to the left side. This coincided with studies of JaydipSenet al[19] on BangaleseRajbhashi population and KewalKrishan et al[10] on Himachali population. However, Barnabas et al[13] on Nigerians and Agnihotri et al[12] observed higher mean foot indices on left side in males. But our results disagree with Agnihotriet al[12] (Mauritian population) who observed higher foot index on left side in males. This may be because of environmental and genetic differences.

The sample of our study considered of 150 male medical students. Out of 150 males studied 140 (93.33%) were right footed and 10 out of 150 were found to be left footed (6.6%). Yamaner et al[2] in his study of evaluating foot morphology depending on foot preference has documented 328 of 407 male football players to be right footed and 79 to be left footed. Carey et al found 79% right footed and 21% left footed out of 236 players they studied in France world cup 1998. However, Zverev et al and Spry et al[21] have reported a mixed footed group of 10.7% and 9.21% respectively. Zverev et al reported 81% right footed and 8.3% left footed of the 205 (112 males and 93 females) cases studied and Spry et al[21] documented 39 right leg dominant and 30 left leg dominant of 76 cases studied. In comparision to all these studies mentioned we have observed higher preponderance of right sided individuals (90%).

Table 2.5:- Comparison of Mean Foot dimensions of right foot preference group in males

Author	No.	Side	Right Foot Preference Group		
			Foot height	Foot breadth	Foot length
Present study	140	RF	7.07±0.75	9.48±0.55	25.85±1.33
		LF	7.22±0.73 (p<0.05)	9.53±0.52	26.05±1.53 (p<0.05)
Yamaner et al[2]	328	RF	6.17±0.59	10.14±0.47	26.77±1.08
		LF	6.19±0.64	10.20±0.58 (p<0.05)	26.84±1.12 (p<0.05)

In the present study, all the dimensions of left foot (foot height, foot breadth and foot length) of left foot were more than that of right foot in the right foot preference group. These results are in accordance with Yamaner et al in which left foot parameters were also larger on left side. These findings could be suggestive of the fact that the non

dominant i.e. left sided measurement are more in the right footed individuals as the left side is used more for maintaining posture and balancing the weight of the body.

The right and left foot height of present study group were height than that of Yamaner et al on Turkish foot ball players. But measurements of right and left foot breadth and foot length of present study group were lower than that of Yamaner et al group. This may be because of racial and sample difference. So, it can be inferred from the study that Turkish players feet were much wider and longer than the Indians in the right footed group.

Table 2.6:-Comparison of Mean Foot dimensions of Left foot preference group in males

Author	No.	Side	Right Foot Preference Group		
			Foot height	Foot breadth	Foot length
Present study	10	RF	6.60±0.74	9.67±0.86	25.80±1.33
		LF	6.83±0.58	9.73±0.73	26.03±1.11
Yamaner et al[2]	79	RF	6.15±0.61	10.01±0.48	26.48±1.24
		LF	6.10±0.66	10.11±0.53 (P<0.05)	26.53±1.28

When the left foot preference was examined it was seen that all the somatometric measurements (foot height, foot breadth and foot length) of the left foot were more than that of right foot. However, these findings cannot be considered to be statistically significant as the sample size is too small (n=10). Our results coincided with the studies of Yamaneret al.[2] in which left foot parameters were also larger on the left side except the foot height which was larger on right side.

The right and left foot height of left foot preference group of present study were higher than that of the Yamaner et al on Turkish football players. But the measurements of right and left foot breadth and foot length of present study group were lower than that of Yamaner et al group. This may be due to racial and sample differences.

Conclusion:-

On comparison of the foot indices of the present study group with the other local and international study groups it was found that

1. The mean foot length in the present study is longer than the mean foot length of the other local population groups studied in India; however, it is lesser when compared with other international study groups.
2. No specific correlation for the mean foot breadth could be found when it was compared with mean foot breadth with some of the local population groups in India and other international study groups.
3. The mean foot height was found to be higher than the local and international study groups
4. The foot index in the present study was found to be less than the local population groups in India; however, when compared with international study groups no specific conclusion could be drawn as it was almost same for one study and was higher than the other study group.
5. Mean foot dimensions of the right footed and left footed subjects were compared with a single international study and it was found these indices were higher in our study group.

Competing interests:-

There are no competing interests.

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Author contributions:-

1. SanjeevThankyal

Was the chief investigator.

2. MunishKhanna(corresponding author)

Analyzed and interpreted the data

3. Shifalli M Rustagi
Gave the guidance

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