Original Article

Gender Determination Using Foot Measurements of Koya and Konda Reddi Tribal Children of Andhra Pradesh

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Abstract

Background: This study assesses an individual's gender using foot parameters, which are invaluable tools for personal identification. 360 tribal children of Andhra Pradesh state were included in this study. The age group of the children was between 3 and 15 years. Foot index was calculated from foot length and foot width measurements of individual subjects. Mean foot length in males was 19.98± 2.69 cm, and in females was 19.28± 2.5 cm. In males, the foot breadth was 8.06±0.95 cm, and in females, it was 7.62±0.85cm. The mean foot index in males was 40.49±2.07 cm, and in females it was 38.6±0.92 cm. All the foot parameters showed significant gender differences. These differences in parameters act as a template for tribal children of Andhra Pradesh and would help identify the individual.

Keywords: Foot measurements, foot index, identification, sex determination.

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Introduction

Despite modernization, the deep connection to nature is still maintained in the Koya and Konda Reddi tribes. Koya and Konda Reddi are the two indigenous tribal groups whose root of origin extends to Bastar, Northern India, but who migrated to live in and around the Godavari region. Due to earlier ossification of foot bones compared to long bones of the body and the better reliability of stature estimation using foot length and foot breadth, foot anthropometric studies play a significant role in individual identification. Conditions of natural disasters, accidents, and mutilated bodies warrant the recognition of a body using available body parts. India ranks as the third global country in natural disasters due to varied climate changes, only next to China and the United States. In this country, where such instances are more prone, there is a need to have a pool of specific anthropometric data that would help in gender determination. This study aims at measuring foot index from foot parameters and evaluates the gender differences, if any.

Materials and Methods

Ethical committee clearance was obtained from Maharishi Markandeshwar Institute of Medical Sciences, Mullana, Ambala. Tribal children from the East Godavari District of Andhra Pradesh were involved in this study. Prior permission was obtained from school authorities and parents. Foot length and foot width measurements were noted using an osteometric board. The material consists of 360 healthy tribal children of 3-15 years of age, which include 180 males and 180 females.

Foot length: The distance between the acropodion, which is the most forward-projecting point on the head of the first or second toe, depending on which is larger when the subject is standing upright, and the pternion, which is the most backward-projecting point on the heel when the subject is standing upright with equal pressure on both feet, was used to calculate foot length.[2]

The distance between the medial metatarsal point, which is the most noticeable portion of the head of the first metatarsal bone, and the lateral metatarsal point, which is the most noticeable point of the head of the fifth metatarsal bone, is the foot's width.[3]

The total research sample has been divided into many age groups, such as 3 to ≤4 years, 4 to ≤5 years, 5 to ≤6 years, and 14 to ≤15 years, to improve the findings. The foot index has been calculated using the average foot length and foot width of each age group. By dividing the foot length by the foot width and multiplying the result by 100, the foot index was determined.[4]

The AGD Seropak Stained Antigen kit were procured and tested for Salmonella typhi and S. paratyphi Antibody by Widal test using the principle of Slide Agglutination

Results

Findings: Male foot lengths ranged from 14.4 cm to 27.2 cm for

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the right foot (mean 19.98 & SD 2.69) and from 14.4 cm to 27.2 cm for the left foot (mean 19.98 & SD 2.69). The lengths of the girls' right and left feet ranged from 13.5 to 23.8 cm (mean 19.27 & SD 2.5) and 13.5 to 23.8 cm (mean 19.28 & SD 2.5), respectively. [Table 1]

Foot width: In men, the left foot breadth ranged from 6.00 to 10.30 cm (mean 8.06 & SD 0.95), whereas the right foot breadth ranged from 6.00 to 10.20 cm (mean 8.06 & SD 0.95). The width of the girls' right and left feet ranged from 5.30 to 9.50 cm (mean 7.61 & SD 0.850) and 5.30 to 9.50 cm (mean 7.62 & SD 0.85), respectively. [Table 1]

In men, the left foot breadth ranged from 35.24 to 45.83 (mean 40.49 & SD ± 2.02), whereas the right foot index ranged from 34.29 to 46.49 (mean 40.49 & SD ± 2.07). In females, the left foot width ranged from 34.40 to 44.60 (mean 39.66 & SD ± 2.02), while the right foot breadth ranged from 34.86 to 44.77 (mean 39.64 & SD ± 2.06). [Table 1]

All the foot parameters have shown significant gender differences analysed using a paired t-test, as shown in [Table 2]

The age-wise distribution of the foot index for male and female tribal children was depicted in [Tables 3 & 4]. A gradual trend in reduction of foot index was noted as the age advanced. Significant gender differences were appreciated in right and left foot indices, as shown in [Table 5]. Foot index was greater in males compared to females.

Table 1: Descriptive statistics of foot parameters for male and female tribal children of Andhra Pradesh

Parameters	Male (n=180)			Female (n=180)		
	Minimum	Maximum	Mean±S.D.	Minimum	Maximum	Mean±S.D.
FLR	14.40	27.20	19.98 ±2.69	13.50	23.80	19.28±2.51
FLL	14.40	27.20	19.99±2.70	13.50	23.80	19.28±2.51
FWR	6.00	10.20	8.06±0.95	5.30	9.50	7.61±0.85
FWL	6.00	10.30	8.07±0.95	5.30	9.50	7.62±0.86
FI RIGHT	34.29	46.49	40.49±2.07	34.86	44.77	39.64±2.06
FI LEFT	35.24	45.83	40.49±2.02	34.40	44.60	39.66±2.02

Table 2: Independent t-test showing to note the mean differences in foot parameters among male and female tribal children of Andhra Pradesh

Parameters	T	Df	Sig (2-tailed)
FLR	**2.572**	**358**	**0.011**
FLL	2.562	358	0.011
FWR	4.700	358	0.000
FWL	4.642	358	0.000
FIR	3.905	358	0.000
FIL	3.910	358	0.000

Table 3: Male Foot Index Distribution by Age (n=180)

Male	Foot Index Right				Foot Index Left			
Age (in years)	Mean	SD	Min	Max	Mean	SD	Min	Max
3	41.58	2.10	38.51	45.75	41.52	2.09	38.51	45.75
4	41.70	1.08	40.51	43.45	41.72	1.19	40.34	43.87
5	41.61	2.50	37.14	45.45	41.74	2.53	37.14	45.45
6	41.30	2.25	38	46.07	41.33	2.03	38.46	45.81
7	41.93	2.30	38.46	46.49	41.86	1.90	38.46	45.83
8	41.09	1.10	38.46	43	41.09	1.16	38.46	43
9	38.87	1.47	36.77	41.06	38.92	1.45	36.77	41.06
10	39.06	1.52	36.36	42.22	39.10	1.54	36.36	42.41
11	40.11	1.52	36.89	41.95	40.07	1.56	36.44	41.9
12	40.32	1.53	38.29	43.1	40.20	1.57	37.84	42.86
13	38.89	1.75	34.29	40.82	38.96	1.59	35.24	40.82
14	39.38	1.58	36.73	42.17	39.40	1.57	36.76	42.17
Total	40.49	2.07	34.29	46.49	40.49	2.02	35.24	45.83

Table 4: Age Wise Distribution of Foot Index in Females (n=180)

Female	Foot Index Right				Foot Index Left			
Age (in years)	Mean	SD	Min	Max	Mean	SD	Min	Max
3	40.89	2.07	37.06	43.84	40.76	2.07	37.06	43.84
4	40.91	1.87	38.27	44.52	41.02	1.75	38.27	44.44
5	40.04	1.63	37.14	42.86	40.08	1.71	37.14	43.43
6	41.22	1.43	38.66	42.86	41.20	1.40	38.66	42.86
7	40.78	1.86	36.54	43.6	40.76	1.82	36.54	43.6
8	40.45	2.58	36.79	44.77	40.43	2.54	36.79	44.25
9	38.75	1.18	36.92	40.93	38.74	1.14	36.73	40.93
10	38.42	1.61	35.09	41.58	38.60	1.51	35.96	41.58
11	38.54	2.23	34.86	44.6	38.56	2.25	34.4	44.6
12	38.65	2.02	35.56	42.6	38.71	1.90	35.4	42.22
13	38.48	1.47	36.61	41.86	38.48	1.38	36.44	41.86

14	38.51	0.74	36.94	39.81	38.60	0.92	36.6	39.81
Total	39.64	2.06	34.86	44.77	39.66	2.02	34.4	44.6

Table 5: Independent-test to show gender differences in foot index between males and female tribal children of Andhra Pradesh

Foot Index	Gender	Mean	Std. Deviation	Std. Error Mean	t-test	Sig
Right	Female (n=180)	39.64	2.06	0.15359	-3.905	0.000
	Male (n=180)	40.49	2.07	0.15435		
Left	Female (n=180)	39.67	2.01	0.15030	-3.910	0.000
	Male (n=180)	40.5	2.01	0.15029		

Forensic expertise comes into play where the identification of an individual needs to be done using the body fragments found in decomposed and mutilated states. Many instances, like earthquakes, accidents, and murders, where the body parts are found, warrant the identification of available remains.

Identification of sex is the prime aspect of analysis. Several research projects are going on for assessment of stature, sex, race, etc. from anthropometric measurements. This study attempts to find out the correlation of foot measurements with the sex (male/female).

Discussion

Foot length & foot width were well known for their gender differences, supporting the differences in general physique between males and females. In agreement with this research, which found that male tribal children had longer feet than female children, Shugaba et al. (2013) evaluated the relationship between foot characteristics and height and weight in Nigerian schoolchildren aged three to five. Males' feet were found to be wider and longer than those of females. Genetic and dietary factors were blamed for this sexual dimorphism.[5].According to research by Krishan K et al. on teenagers in North India, men's feet were longer than women's. They contend that since foot length ratios are not affected by a person's body type, they may be regarded as a more accurate sex indicator because they are not impacted by stature.[6] Phang SF et al.'s research in Malaysia found that foot measures are a reliable way to estimate sex and stature in forensic investigations. They contend that foot length is a more reliable indicator of sex and height than foot breadth.[7] Fessler et al. observed that females had shorter feet than males, a phenomenon known as intersexual selection.[8] Islamia OS found substantial gender variations in foot length and foot width in a 2009 study of 500 Nigerian undergraduates between the ages of 18 and 29. Males had longer feet than females, while females had wider feet.[9] sexual variations in foot characteristics were shown to be significantly significant by Jakhar et al.[10] Our research confirmed previous findings that men had a higher foot index than females. Men had broader and longer feet than females, according to research by Kumari J et al. on 100 men and 100 females over the age of 18 in Ataria, Sitapur, U.P.[11] Because the size of the foot varies significantly between the sexes, it is a crucial component of human identity. Tyagi et al. found a positive correlation between a person's gender and foot measurements. As a result, foot index may accurately predict sex.[12] On the other hand, Moudgil R noted that females had a slightly higher foot index in their right foot compared to their left foot. According to the research, sex determination cannot be achieved definitively from the foot index, even if foot length and foot width demonstrate substantial sex differences.[13] In the Gujarati population aged 17 to 21, Parekh et al. (2014) found substantial gender disparities, with men having a longer mean foot than girls.[14] For both male and female Igbo people from Nigeria, Ewunonu et al. found that the right foot was longer and wider than the left. This difference was shown to be statistically significant in females.[15] Compared to female youngsters, male children's feet were wider and bigger. Chiroma et al. (2016),[16] measured the foot length, breadth, and height of Nigerian Yoruba pupils. To ascertain the form of the foot, they also computed the foot index. All foot metrics showed greater values for men, indicating a gender difference. Males in this research were shown to have longer and wider feet, which was explained by genetics. According to Razeghi and Batt, environment and individual lifestyle will cause changes in foot shape.[17] Foot anthropometry helps design footwear that offers proper support, matches natural biomechanics, and reduces the risk of injuries. Foot length and width are correlated with body mass, and foot shape can change with body weight, which is relevant for children and adults. Wearing properly fitted shoes based on length and width is important for maintaining alignment, reducing fatigue, and preventing conditions like bunions and hammertoes.

Conclusion

This study provides significant data regarding foot measurements of children with tribal origin. This population living in remote areas adds a significant value for this study, as the feet in them were not subjected to external forces like urban styles of shoe wearing. Further research is warranted to establish baseline data about foot parameters.

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Conflicts of interest

There are no conflicts of interest.

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