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Bilateral Foot Asymmetry and Sexual Dimorphism in Young-Adult Igbo People of South-Eastern Nigeria

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ABSTRACT

Differences in foot dimension exist within and across both sexes. The physical differences that exist in the right foot and left foot dimensions in both male and female subjects were quantitatively analyzed. The foot length and foot breadth of 504 subjects, comprising 254 male and 250 female students of Ebonyi State University, Abakaliki whose age range falls between 18 years and 30 years were measured and the values recorded and noted. The result shows that males have significantly higher values of foot length and foot breadth than females ($p < 0.05$). The mean values for the right and left foot length of males were 26.40 ± 1.39 cm and 26.28 ± 1.40 cm respectively while their right and left foot breadth were respectively 8.77 ± 1.27 cm and 8.64 ± 1.26 cm. In females, the mean values for the right and left foot length were 24.49 ± 1.26 cm and 24.36 ± 1.26 cm respectively while their mean values for the right and left foot breadth were 8.02 ± 1.15 cm and 7.90 ± 1.15 cm respectively. This is expected to form a nomogram for reference values in forensic anthropometry.

Keywords: Bilateral, Asymmetry, Dimorphism, Foot length, Foot-breadth.

1. Introduction

Bilateral asymmetry is defined as the difference between the measurements of the left and right sides of the human body [1]. Bilateral asymmetry of the limbs have been studied by many authors. Reports have shown that morphology (both size and shape) of paired structures differ in the left and right sides of the body [2, 3]. Some of such reports have indicated that statistical significant bilateral asymmetry exists in total upper extremity length, upper arm length, forearm length, total lower extremity length and lower leg length [1]. Other reports have shown that bilateral asymmetry is exhibited in both use and size of the upper limb, favoring the right side [4, 5] and a smaller but systematic directional asymmetry in the human lower limb, favoring the left side especially in the femur [5-7]. This trend has been termed as 'crossed symmetry' pattern between contralateral limbs [5, 7]. The studies added that bones of the hand and foot are heavier on the left side and that the left bones are more variable in weight and length while the upper extremity and its individual components manifest more asymmetry than the lower limb. However, some other reports did not find any bilateral asymmetry in measurements of foot length in an individual [8, 9].

Also, sex differences in foot morphology have been studied by many investigators [2, 3, 10-12]. Studies have shown that the normal human foot shows great individual variation in length, width and generally in males and females [13, 14]. Frey reported that women generally tend to have a narrower heel in relation to the forefoot and narrow feet than men relative to length [15]. Baba concluded that proportional to stature, women have larger feet than men [16]. Other investigators are of the opinion that generally, men have longer and broader feet than women for a given stature [17-21]. However, Auerbach and Ruff concluded that the lower limb demonstrates little sexual dimorphism in asymmetry [5].

The present study was undertaken to observe and document the differences in the dimensions of the left and right feet as well as in both sexes in young adult Igbo people of Southeastern Nigeria. The study is important since as in other parts of the body (skeleton), these variations are population based and change with time¹. This is generally important in forensic applications and orthopedics as well as in shoe industries.

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2. Materials and Methods

2.1 Sample

The study was conducted on a sample of five hundred (504) young adult Igbo people of South-Eastern part of Nigeria, resident in Abakaliki, comprising 254 males and 250 females. Their ages ranged from 18 years and 30 years. The foot dimensions were measured directly with a sliding caliper and a meter rule.

2.2 Method

The foot dimensions were measured with foot placed on a horizontal flat surface while the subject was standing erect in

anatomical position and bare-footed. The maximum foot length was measured as the direct distance from the most posterior point of the heel (*pternion*) to the most anteriorly projecting point of the longest toe ie. first or second toe (*acropodion*)^[22]. The foot width was measured as the distance between the medial margins of the head of the first metatarsal and the lateral margin of the head of the fifth metatarsal^[22]. Both right and left foot were measured. Prior informed consent was obtained from the subjects before the measurement. Subjects under 18 years of age and those with apparent foot anomalies, inflammation, trauma, deformities and surgery (if any) were excluded from the study.

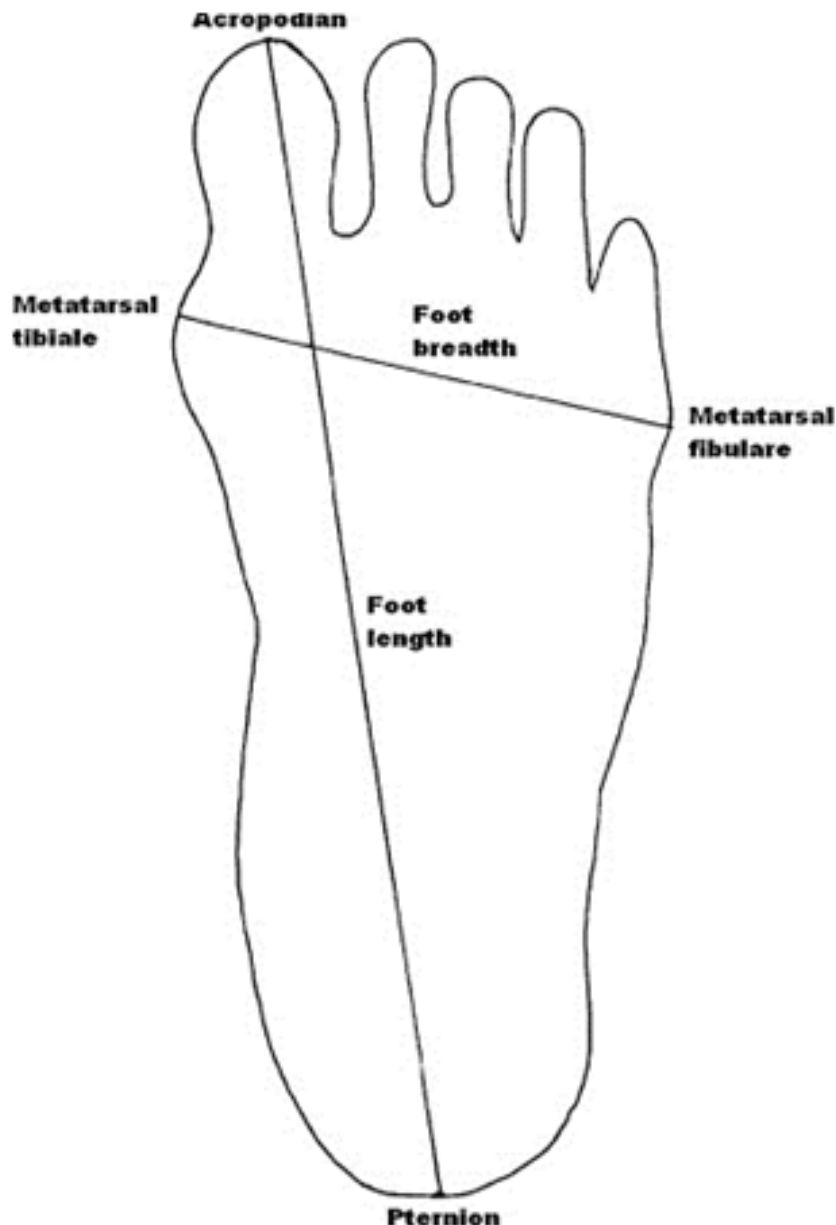


Fig 1: A diagram showing the landmarks and measurements on foot, modified after *Kanchan et. al.*²³.

2.3 Statistical analysis

The data obtained were computerized and subjected to statistical

analysis like Mean, Standard Deviation (S.D.). Student t-test was used to show significant difference.

3. Result

Table 1: Descriptive Statistics of Foot Length and Foot Breadth of Young-Adult Male and Female Igbo Subjects in cm

< Male = 254 >				
	Min	Max	Mean	Std. Dev.
Age (Years)	18.00	54.00	25.05	2.60
Rt. Foot Length	22.40	29.40	26.40	1.39
Lt. Foot Length	22.20	29.30	26.28	1.40
Rt. Foot Breadth	6.20	12.10	8.77	1.27
Lt. Foot Breadth	6.00	12.00	8.64	1.26
P > 0.05				

< Female = 250 >				
	Min.	Max.	Mean	Std. Dev.
Age (Years)	18.00	40.00	23.12	2.19
Rt. Foot Length	20.00	28.20	24.49	1.26
Lt. Foot Length	20.00	28.10	24.36	1.26
Rt. Foot Breadth	5.20	10.80	8.02	1.15
Lt. Foot Breadth	5.10	10.80	7.90	1.15
P > 0.05				

Table 2: Descriptive Statistics of Foot Length and Foot Breadth of Young-Adult male Igbo Subjects in cm by Age

	Age	N	Mean	Std. Dev.	Min.	Max.
Rt. Foot-length (cm)	18-20	77	26.42	1.39	23.10	29.30
	21-23	116	26.35	1.37	22.40	29.40
	24-26	45	26.48	1.58	22.50	29.10
	27-30	16	26.44	1.05	25.00	28.40
	Total	254	26.40	1.39	22.40	29.40
Lt. Foot-length (cm)	18-20	77	26.30	1.42	23.00	29.20
	21-23	116	26.23	1.38	22.20	29.30
	24-26	45	26.38	1.58	22.40	29.00
	27-30	16	26.33	1.05	24.90	28.30
	Total	254	26.28	1.40	22.20	29.30
Rt. Foot-width (cm)	18-20	77	8.80	1.32	6.40	12.10
	21-23	116	8.88	1.29	6.20	11.50
	24-26	45	8.65	1.19	6.40	11.00
	27-30	16	8.98	1.08	6.30	11.10
	Total	254	8.77	1.27	6.20	12.10
Lt. Foot-width (cm)	18-20	77	8.66	1.32	6.30	12.00
	21-23	116	8.64	1.28	6.00	11.30
	24-26	45	8.51	1.20	6.20	11.80
	27-30	16	8.84	1.10	6.10	11.00
	Total	254	8.64	1.26	6.00	12.00

P > 0.05

Table 3: Descriptive Statistics of Foot Length and Foot Breadth of Young-Adult Female Igbo Subjects in cm by Age

	Age	N	Mean	Std. Dev.	Min.	Max.
Rt. Foot-length (cm)	18-20	114	24.68	1.32	21.50	28.20
	21-23	104	24.35	1.24	20.00	27.90
	24-26	25	24.44	1.07	21.80	26.70
	27-30	7	23.50	0.52	22.80	24.20
	Total	250	24.49	1.26	20.00	28.20
Lt. Foot-length (cm)	18-20	114	24.56	1.33	21.30	28.10
	21-23	104	24.04	2.47	22.00	27.80
	24-26	25	24.33	1.09	21.60	26.60
	27-30	7	23.39	0.53	22.70	24.10
	Total	250	24.36	1.26	22.00	28.10
Rt. Foot-width (cm)	18-20	114	8.10	1.16	5.40	10.20
	21-23	104	7.98	1.16	5.20	10.80
	24-26	25	7.86	1.15	6.30	9.70
	27-30	7	7.70	1.05	6.20	9.30
	Total	250	8.02	1.15	5.20	10.80
Lt. Foot-width (cm)	18-20	114	7.98	1.16	5.30	10.10
	21-23	104	7.87	1.15	5.10	10.70
	24-26	25	7.72	1.17	6.10	9.60
	27-30	7	7.57	1.07	6.00	9.20
	Total	250	7.90	1.15	5.10	10.70

$P < 0.05$

Table 1 shows the descriptive statistics of the foot length and foot breadth of the young-adult Igbo subjects.

Table 2 shows the descriptive statistics of the foot length and foot breadth of the male young-adult Igbo subjects by age while table 3 shows that of the female. The two tables present the right foot to be longer and broader than the left. This result is not significant ($P > 0.05$) in males but significant ($P < 0.05$) in females.

4. Discussion

This study was carried out to demonstrate the bilateral asymmetry and sexual dimorphism of foot dimensions among the young adult Igbo Nigerians resident in Abakaliki, Ebonyi State.

Bilateral asymmetry, the difference between the measurements of the left and right sides of the human body has been studied by several authors¹. The normal human foot has been demonstrated to show great individual variation in length and width on both sides of the body and in both sexes^[13, 14]. The present study shows that generally, in both males and females, right foot is longer and broader than left foot (Tables 1, 2 and 3). This result is however, insignificant for males ($P > 0.05$) but significant for females ($P < 0.05$). This finding seems to be supported by the behavioral studies of lower limb laterality which consistently indicated higher frequencies of right-footedness^[24-27]. However, the present finding with the report on behavioural studies, contradicts the other reports on similar studies which indicated that bones of the foot are heavier on the left side^[5-7, 28, 29]. According to such reports, “preferred foot” is the foot utilized for object manipulation or other activities involving motor coordination^[5] while the contralateral “non-

preferred” lower limb is used for “postural and stabilizing support” during such activities and may actually be subjected to higher mechanical loads than the “preferred” limb^[25, 26]. Auerbach and Ruff reported that Faulkner *et al.*, found slightly but significantly elevated bone mineral mass in the “non-dominant” (ie. non-preferred) lower limb in children, thereby making the non-preferred foot of such individuals to be heavier or longer than the preferred foot^[5, 30]. Hence, for right-footed individuals, their left foot appear longer than their right foot. This interpretation however, may not be adduced as the reason for the difference in the measurements of the left and right feet in the present report. This is because, the interpretation when strictly applied, may suggest that the subjects used in the present study might have been left-footed. The present report may rather be as a result of genetic factors and effects of cerebral dominance on lateral preference for the right foot. On the other hand, previous reports have shown that studies using hands and feet measurement indicated that the bilateral variation was insignificant for all the measurements in both the sexes as Jakhar *et al.* working on the estimation of height from measurements of foot in Haryana region of India did not find any bilateral asymmetry in measurements of foot length in an individual^[9]. Similar findings were reported in earlier studies in other places^[8, 31].

On sexual dimorphism, the present study on the linear measurement of the foot length and foot breadth showed marked difference that suggested that the mean values of male foot dimensions are larger and broader than the female. The present finding is in conformity with earlier reports. Ashizawa *et al.* and

Wunderlich and Cavanagh had in their respective studies reported that males have longer and broader feet than females for a given stature [19, 21]. Also, earlier reports on adult Nigerian subjects indicated that males had significantly higher values of foot length and foot breadth than the females [32]. Reports have shown that significant differences in stature and foot measurements between males and females can be attributed to the fact that fusion of epiphyses of bones occurs earlier in girls in comparison to boys. In other words, boys have about two more years of bony growth than girls, which were expressed in male surpass of the somatometric measurements of the adult [33]. This in effect explains the reason for the sex differences observed in the foot dimensions studied in the present report.

5. Conclusion

The present study has successfully, demonstrated the incidence of bilateral asymmetry and sexual dimorphism in foot dimensions of young adult Igbo subjects in Abakaliki, Ebonyi State. The study indicated that in both males and females, right foot is longer and broader than left foot among the subjects studied. Also, the mean values of male foot dimensions were larger and broader than the female.

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