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Estimation of Sex Using Antero-posterior Dimension of Talus in North Eastern Nigerians

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Authors' contributions

This work was carried out in collaboration between all authors. Author ESO was involved in conception and design of the study and collection of data. Author AAR did first manuscript writing. Author ZM managed provision of study materials/radiograph and selection of normal Radiographs. Author DSA did data analysis and interpretation of results. Author TWJ did final approval of manuscript and author MA did the literature searches.

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ABSTRACT

Aim: To evaluate sexual differences using demarking point and index of sexual dimorphism from the length of talus in relation to age among male and female north-eastern Nigerians.
Study Design: Retrospective Study.
Place and Duration of Study: Departments of Human Anatomy and Radiology, University of Maiduguri and University of Maiduguri Teaching Hospital (UMTH) respectively, Borno State, Nigeria between October 2010 to March 2012.
Methodology: Three hundred and twelve (312) radiographs of adult north-eastern Nigerians (156

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males and 156 females) with ages ranged from 20 to 69 years were measured. Radiographs used for this study were obtained from the collection of records unit of Radiology Department of UMTH in Borno State, Nigeria. Radiographic viewing box, erasable maker, meter rule were used for the measurements. Both female and male samples were grouped into two separate subsamples (right and left talus). Samples were classified into five (5) age groups which spanned ten years interval. The lateral views of the plain radiographs of the ankle were mounted on viewing box connected to a light source which gave good illumination. Antero-posterior length (APL) of the talus was measured as a linear distance between the most anterior point on the head of talus and the most posterior point on the body of the talus) using a calibrated meter rule.

Results: The means of APL for males are all significantly greater than their female counterparts of the same age group. The results also show statistically significant ($p<0.001$) differences between the lengths of talus in males and females. The values of demarking points (DP) in males were higher than in females. The Index of sexual dimorphisms (ISDs) are greater than 100 which suggest that males have higher value over female counterparts. The result also show age related variation with male APL range from 5.82 cm at 60-69 years age group to 6.21 cm at 30-39 years age group; while female APL range from 5.27 cm at 60-69 years age group to 5.56 cm at 30-39 years age group.

Conclusion: It was observed that the APLs of talus are sexually dimorphic; the DPs of male are all higher than those of female Counterparts. ISD also shows that, male APLs are greater than those of the female counterparts: because the ISDs were all greater than 100 at all age groups. However more studies are required in other part of Nigeria, so as to capture the racial variation of Nigeria.

Keywords: Sex determination; demarking point; index of sexual dimorphism; Antero-posterior length; talus; North-Eastern Nigerians.

1. INTRODUCTION

Shallow or Surface burials normally lead to loss of skeletal materials and this can greatly impede on investigations. Unlike the skull and long bones, the compactness and the associated soft tissues (ligaments) make the talus more resistance to taphonomic factors, thus increasing its chances of preservation and eventual field recovery. In cases requiring post-mortem identification and there is scarce skeletal material talus can be used for osteological analysis because it can relatively withstand decay [1].

The field of forensic anthropology involves the building of an ante mortem profile of an individual from skeletal remains. This involves sex, race determination; age and stature estimation. Because most bones that are conventionally used for sex determination, age and stature estimation are often recovered either in fragments or in incomplete state, it has become necessary to use denser bones that are often recovered almost intact such as the patella, calcaneus and talus [2].

Determination of human remains by sex and age has been a challenge for the medico-legal profession. Metrical study of bones has been studied by many authors [3]. Jit and Singh [4] advocated that Demarking Point (DP) can identify the sex of the subjects with 100% accuracy. Singh and Gangrade [5] reported that even within the same general population, mean value may be significantly different in bones from different zones. Singh and Singh [6] observed that DP should be calculated separately for different region of population, because the mean of parameter, may differ in values.

To be certain in identification, calculated ranges have to be considered, which can be worked out by adding and subtracting 3 X standard deviation (SD) to and from the mean of any parameter. Jit and Singh [4], called the limiting point of such calculated range: Demarking point, which identify sex with 100% accuracy from any given population or region, hence the need for this study to evaluate sexual differences using Demarking Points (DPs) and Index for Sexual Dimorphisms (ISDs) of the length of the talus in relation to age of males and females in north eastern Nigerians.

2. MATERIALS AND METHODS

This retrospective study used radiographs obtained from the collections of the records unit of Radiology Department University of Maiduguri Teaching Hospital (UMTH) in Maiduguri, Borno State, Nigeria, over a period of five years (2005-2010). The distance between the cassette and

the X-ray tube was 5 mm; hence magnification obtained was 0.1 mm (0.01 cm). Only radiographs that were reported by a consultant radiologist as normal without any bone defect were used for this study. Plain lateral X-ray radiographs of the ankle for three hundred and twelve (312) subjects (156 males and 156 females) with age ranged from 20 to 69 years were measured. Both female and male subjects were grouped into two separate subsamples (right and left talus). Samples were classified based on their ages which spanned ten years interval (Table 1). Each patient's age and sex were taken directly from the film jackets. Radiographic viewing box, erasable maker, calibrated meter rule were used for the measurements. The viewing box was connected to a light source which gave good illumination.

Table 1. Distribution of subjects according to age groups

Age group (years)	Males		Females		Total
	Right	Left	Right	Left	
20-29	16	16	16	16	64
30-39	15	15	15	15	60
40-49	17	17	17	17	68
50-59	15	15	15	15	60
60-69	15	15	15	15	60
Total	78	78	78	78	312

Antero-posterior length (APLs) in centimeters was taken on each talus. Erasable marker was for noting the points of measurements while a calibrated meter rule was used for the measurements. Each measurement was taken three times and an average was computed. The methods adopted for the measurements were a modification from Ari and Kafa [7]. The X-ray films were mounted on a viewing box. The margins of the talus were well outlined and the most anterior point on the head and the most posterior point on the body were marked by erasable marker. Then the linear distance between the two points were measured by a transparent calibrated meter rule in centimeter as APL (Fig. 1). All the measurements were taken directly on the radiographs [8,9].

2.1 Statistical Analysis

Data obtained from the measurements were analyzed using Graph pad InStat3 [10]. The average taken from all the variables measured were grouped into right and left sides and were used in the analysis. The means and standard deviations were determined using two way analysis of variance (ANOVA) and statistical differences between mean diameters of both sexes. The significant differences in the means of the parameter (APL) and indices were determined using paired sample student t- test and a p value of <0.05 (two tailed) was considered significant. However a probability level of less than 0.001 ($p<0.001$) was considered extremely significant; $p<0.01$ was

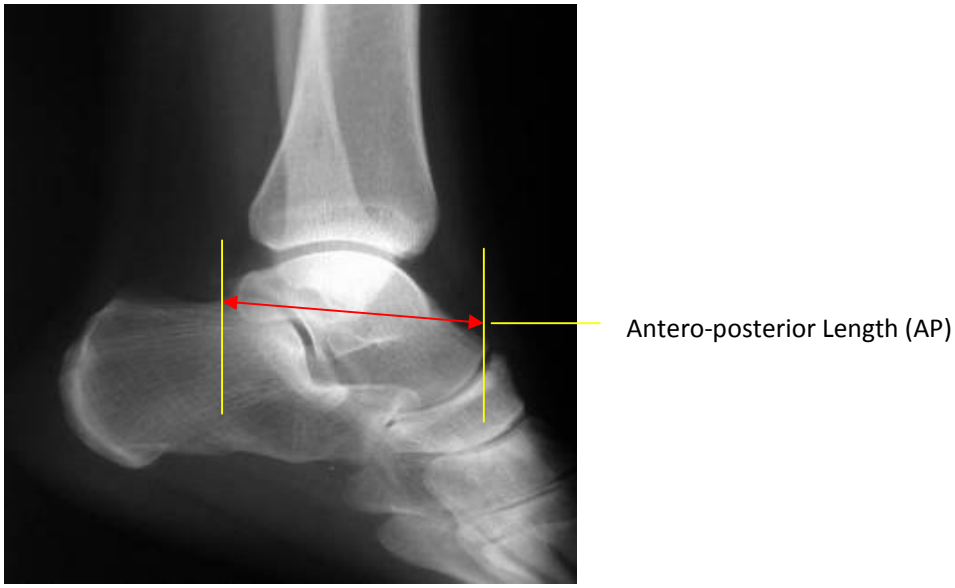

Fig. 1. Lateral radiograph of the ankle showing antero-posterior length (red line): (Ryan et al., 2009)

very significant; $p<0.05$ was significant while $p>0.05$ was not significant. Demarking points were calculated for males and females from the formula: mean ± 3 standard deviation, which gave calculated ranges for both males and females. From the calculated range, the demarking points were obtained.

Values for Index for Sexual Dimorphism (ISD) were obtained using the formula

$$ISD = \frac{\text{Male Mean}}{\text{Female Mean}} \times 100\% \quad [18]$$

Values for CR and DP were obtained using the formula = Mean ± 3 x Standard Deviation

3. RESULTS AND DISCUSSION

3.1 Analysis of Results for Antero-posterior Length of the Right Talus in Males and Females

The APL of the right talus between male and female was compared. It was observed that male value ranged from 5.82 cm at 60-69 years age group to 6.24 cm at 30-39 years age group: while female mean value ranged from 5.27 cm at 60-69 years age group to 5.57 cm at 30-39 years age group. There are statistically significant differences among males and females ($p<0.001$) (Table 2).

3.2 Analysis of the Results for Antero-posterior Length of the Left Talus in Males and Females

The APL of the left talus between male and female was compared. It was observed that male value ranged from 5.81 cm at 60-69 years age group to 6.17 cm at 30-39 years age group: while female mean value ranged from 5.26 cm at 60-69 years age group to 5.55 cm at 30-39 years age group. There are statistically significant differences ($p<0.001$) among males and females (Table 3).

3.3 Analysis of the Results for the APL of the Right and Left Talus in Males

The APL of the right and left talus in male was compared. It was observed that right mean value ranged from 5.82 cm at 60-69 years age group to 6.24 cm at 30-39 years age group: while left mean value ranged from 5.81 cm at 60-69 years age group to 6.17 cm at 30-39 years age group. There are no statistically significant differences ($p>0.05$) among males and females (Table 4).

3.4 Analysis of the Results for the APL of the Right and Left Talus in Females

The APL of the right and left talus in female was compared. It was observed that right mean value ranged from 5.27 cm at 60-69 years age group to 5.57 cm at 30-39 years age group: while left mean value ranged from 5.26 cm to 5.55 cm at the same age group respectively. There are no statistically significant differences ($p>0.05$) among males and females (Table 5).

3.5 DP and ISD for APL of the Right Talus for Male and Female

DPs for the male APL of the right talus ranged from >6.08 cm at 60-69 years age group to >6.35 cm at 30-39 years age group: while the DPs for the female ranged from <5.04 cm to <5.40 cm of the same age groups respectively. ISD at 20-29 years age group was 115.06, 30-39 years age group was 112.03, 40-49 years age group was 111.90, 50-59 years age group was 110-59 and 60-69 years age group was 110.44 (Table 6).

3.6 The DP and ISD for APL of the Left Talus for Male and Female

DP for the male APL of the left talus ranged from >5.95 cm at 60-69 years age group to >6.30 cm at 30-39 years age group: while the DPs for the female ranged from <4.91 cm to <5.39 cm at the same age groups respectively. ISD at 20-29 years age group was 114.88, 30-39 years age group was 111.17, 40-49 years age group was 112.94, 50-59 years age group was 110-82 and 60-69 years age group was 110.46 (Table 7).

Table 2. Descriptive statistics for APL of the right talus in males and female

Age GP (YRS)	Male		Female	
	Mean ± SD (cm)	95% CL (cm)	Mean ± SD(cm)	95% CL (cm)
20-29	6.19±0.32	6.02-6.37	5.38±0.23***	5.26-5.50
30-39	6.24±0.28	6.08-6.40	5.57±0.26***	5.43-5.71
40-49	6.11±0.32	5.59-6.27	5.46±0.29***	5.31-5.61
50-59	5.95±0.24	5.82-6.08	5.38±0.22***	5.26-5.50
60-69	5.82±0.26	5.70-5.99	5.27±0.27***	5.12-5.42

*SD=Standard Deviation; CL=Confidence Limit; GP=Group; P=Probability; CM=Centimeter, *** = P<0.001*

Table 3. Descriptive statistics for the APL of the left talus in males and females

Age GP (Yrs)	Male		Female	
	Mean ± SD (cm)	95% CL (cm)	Mean ± SD (cm)	95% CL (cm)
20-29	6.10±0.29	5.95-6.25	5.31±0.21***	5.20-5.42
30-39	6.17±0.26	6.03-6.42	5.55±0.25***	5.41-5.69
40-49	6.11±0.30	5.95-6.26	5.41±0.26***	5.28-5.55
50-59	5.94±0.30	5.78-6.11	5.36±0.27***	5.21-5.51
60-69	5.81±0.30	5.66-5.97	5.26±0.23***	5.14-5.39

*SD=Standard Deviation; CL=Confidence Limit; GP=Group; P=Probability; CM=Centimeter *** = P<0.001*

Table 4. Descriptive statistics for the APL of the right and left talus in males

Age GP (Yrs)	Right		Left	
	Mean ± SD (cm)	95% CL (cm)	Mean ± SD (cm)	95% CL (cm)
20-29	6.19±0.32	6.02-6.37	6.10±0.29 NS	5.95-6.25
30-39	6.24±0.28	6.08-6.40	6.17±0.26 NS	6.03-6.32
40-49	6.11±0.32	5.95-6.27	6.11±0.30 NS	5.95-6.26
50-59	5.95±0.24	5.82-6.08	5.94±0.30 NS	5.78-6.11
60-69	5.82±0.26	5.70-5.99	5.81±0.31 NS	5.66-5.97

SD=Standard Deviation; CL=Confidence Limit; GP=Group; P=Probability; CM=Centimeter; NS= Not Significant

Table 5. Descriptive statistics for the APL of the right and left talus in females

Age GP (yrs)	Right		Left	
	Mean ± SD (cm)	95% CL (cm)	Mean ± SD (cm)	95% CL (cm)
20-29	5.38±0.23	5.26-5.50	5.31±0.21 NS	5.20-5.42
30-39	5.57±0.26	5.43-5.71	5.55±0.25 NS	5.41-5.69
40-49	5.46±0.29	5.31-5.61	5.41±0.26 NS	5.28-5.55
50-59	5.38±0.22	5.26-5.50	5.36±0.27 NS	5.21-5.51
60-69	5.27±0.27	5.12-5.42	5.26±0.23 NS	5.14-5.39

SD=Standard Deviation; CL=Confidence Limit; GP=Group; P=Probability; CM=Centimeter; NS= Not Significant

Table 6. The DP and ISD for APL of the right talus for male and female

Age GP	Male			Female		D.P	ISD
(Yrs)	Mean±SD (cm)	CR (cm)	D.P(cm)	Mean±SD (cm)	CR (cm)	(cm)	
20-29	6.19±0.32	5.23-7.15	>6.07	5.38±0.23	4.69-6.07	<5.23	115.06
30-29	6.24+0.28	5.40-7.08	>6.35	5.57±0.26	4.79-6.35	<5.40	112.03
40-49	6.11±0.32	5.15-7.07	>6.33	5.46±0.29	4.59-6.33	<5.15	111.90
50-59	5.95±0.24	5.23-6.67	>6.04	5.38±0.22	4.72-6.04	<5.23	110.59
69-69	5.82±0.26	5.04-6.60	>6.08	5.27±0.27	4.46-6.08	<5.04	110.44

SD=Standard deviation; D.P=Demarking point; ISD=Index of sexual dimorphism; CM=Centimeter; YRS= years; GP= Group

3.7 Comparison of the Antero-posterior Length (APL) between Age Groups

The present study showed that the mean APL of the talus changes with increase in age among males and females. The differences between two sexes were significant in some age groups, but not significant in others. The highest value was obtained between the 30-39 and 60-69 years age groups ($p<0.001$) in both males and females. This highest mean values may be attributed to the fact that bone growth continues from birth and accelerates in its maturation as sex hormones level rise during puberty [1,11]. These bones will continue to grow and reach their full maturation at about 25 to 30 years. These mature bones can maintain this state of maturity for about 20 years or more depending on one's lifestyle and feeding habit [11]. It also suggest that bone resorption do not take place immediately after maturation as the integrity of the bone length was still maintained, but undergo degenerative changes at about 50 years. This could be the reason for the significant difference that existed between 30-39 years age group and 60-69 years age group. The lowest mean value of APL was 5.82 cm at 60-69 years age group in males and 5.27 cm in females. This is due to the fact that from birth through adolescence, more bone is produced than is lost during bone remodeling. In young adults, the rate of bone production and loss are about the same but as

the level of sex steroids diminish during middle age especially in women after menopause, a decrease in bone mass occurs because bone destruction outpaces bone formation. Women generally have smaller bones than men; loss of bone mass in old age typically causes greater problems in women. These factors contribute to higher incidence of osteoporosis in women [1].

Table 7. The DP and ISD for APL of the left talus for male and female

Age GP (Yrs)	Male			Female		D.P (cm)	ISD
	Mean ± SD (cm)	CR (cm)	D.P (cm)	Mean ±SD (cm)	CR (cm)		
20-29	6.10±0.29	5.23-6.97	>5.94	5.31±0.21	4.68-5.94	<5.23	114.88
30-39	6.17±0.26	5.39-6.95	>6.30	5.55±0.25	4.80-6.30	<5.39	111.17
40-49	6.11±0.30	5.21-7.01	>6.19	5.41±0.26	4.63-6.19	<5.21	112.94
50-59	5.94±0.30	5.04-6.84	>6.17	5.36±0.27	4.55-6.17	<5.04	110.82
60-69	5.81±0.30	4.91-6.71	>5.95	5.26±0.23	4.57-5.95	<4.91	110.46

SD=Standard Deviation; D.P=Demarking Point; ISD=Index of Sexual Dimorphism; CM=Centimeter; YRS= years; GP= Group

Table 8. Descriptive statistics for APL in both sexes between 20-29 and other age groups (yrs)

Sex	20-29 years		30-39 years	
	Mean ± SD (cm)	95%CL (cm)	Mean ± SD (cm)	95%CL (cm)
Males	6.15±0.06	5.57-6.72	6.21±0.05^{NS}	5.76-6.65
Females	5.34±0.05	4.90-5.79	5.56±0.01**	5.43-5.69
	20-29 Years		40-49 Years	
Males	6.15±0.06	5.57-6.72	6.11±0.00^{NS}	6.11-6.11
Females	5.34±0.05	4.90-5.79	5.44±0.04^{NS}	5.12-5.75
	20-29 Years		50-59 Years	
Males	6.15±0.06	5.57-6.72	5.95±0.01**	5.88-6.01
Females	5.34±0.05	4.90-5.79	5.37±0.01^{NS}	5.24-5.50
	20-29 Years		60-69 Years	
Males	6.15±0.06	5.57-6.72	5.82±0.01**	5.75-5.88
Females	5.34±0.05	4.90-5.79	5.27±0.01^{NS}	5.20-5.33

*SD=Standard Deviation; CM=Centimeter; APL=Antero-posterior length, *** = P<0.001, ** = P<0.01, * = P<0.1 and NS = Not Significant*

Table 9. Descriptive statistics for APL in both sexes between 30-39 and other age groups (yrs)

Sex	30-39 years		40-49 years	
	Mean±SD (cm)	95% CL (cm)	Mean±SD (cm)	95%CL (cm)
Males	6.21±0.05	5.76-6.65	6.11±0.00^{NS}	6.11-6.11
Females	5.56±0.01	5.43-5.69	5.44±0.04*	5.12-5.75
	30-39 Years		50-59 Years	
Males	6.21±0.05	5.76-6.65	5.95±0.01**	5.88-6.01
Females	5.56±0.01	5.43-5.69	5.37±0.01**	5.24-5.50
	30-39 Years		60-69 Years	
Males	6.21±0.05	5.76-6.65	5.82±0.01***	5.75-5.88
Females	5.56±0.01	5.43-5.69	5.27±0.01***	5.20-5.33

*SD=Standard Deviation; CM=Centimeter; APL=Antero-posterior length, *** = P<0.001, ** = P<0.01, * = P<0.1 and NS = Not Significant*

Table 10. Descriptive statistics for APL in both sexes between 40-49 and other age groups (yrs)

Sex	40-49 Years		50-59 Years	
	Mean±SD (cm)	95%CL (cm)	Mean±SD (cm)	95%CL (cm)
Males	6.11±0.00	6.11-6.11	5.95±0.01***	5.88-6.01
Females	5.44±0.04	5.12-5.75	5.37±0.01***	5.24-5.50
	40-49 Years		60-69 Years	
Males	6.11±0.00	6.11-6.11	5.82±0.01**	5.75-5.88
Females	5.44±0.04	5.12-5.75	5.27±0.01*	5.20-5.33
	50-59 Years		60-69 Years	
Males	5.95±0.01	5.88-6.01	5.82±0.01**	5.75-5.88
Females	5.37±0.0	5.24-5.50	5.27±0.01*	5.20-5.33

*SD=Standard Deviation; CM=Centimeter; APL=Antero-posterior length, *** = P<0.001, ** = P<0.01, * = P<0.1 and NS = Not Significant*

The present study also showed mean APLs of talus in male subjects were significantly greater than in female counterpart of the same age group in all the age groups studied. This follows a similar trend observed by Torres [1] that saw a significant difference between the male and female APL of the talus. The higher values in males conform to the fact that males in most cases are physically stronger than females. Since bones are the structures that give strength and rigidity to the body, it means that male bones are supposed to be stronger and bigger than female bones including the talus [12].

The right maximum APLs of the talus were slightly greater than the left maximum APLs of the talus in both sexes, however the difference was not statistically significant ($p>0.05$). This value agreed with Kafa et al. [9] who observed that male maximum APL of the right talus was greater than the left talus. Sarrafin et al. and Oygulu et al. [12,13] observed that the late byzantine era calcaneus and talus had no significant side differences, which support the present study which showed that although the right mean was greater than the left mean, it was not statistically significant. The means APL of both sexes on both sides were seen to be highest in 30-39 years age group but lowest at 60-69 years age group. It was also seen to increase slightly from 20 years to 49 years, but maintained a closed range as it decreased down to 60-69 years age group. This could be attributed to the fact that growth of bones including talus normally stop between the age of 20-30 years [14]. After complete growth, talus bone will remain at mature state for about 20 to 30 years or more after which it atrophied along due to wear and tear leading to reduction in size and perhaps length. The side difference was observed more in males than females. The slight increase in the length of the right talus more than the left could be attributed to more physical activities of the right side than the left side [11]. It was also observed that the APL was sexually dimorphic, since the DPs of the male APL were all higher than those of the female. Index of sexual dimorphism confirmed that male APLs were all greater than female APL as the ISD were all greater than 100 in all the age groups. DPs showed a similar trend of increase in male parameters over their female counterparts of the same age group. This sex difference can be as a result of genetic and environmental factors affecting growth and development (nutrition, physical activities, hormones and pathologies), or the interaction of these factors [9]. These parameters placed talus as a useful bone in sex determination among adult north-eastern Nigerians particularly where other bones commonly used for sex determination of individual from skeletal remains such as pelvic and skull are not found. The measurements of the talus for identification of sex by several researchers is not applicable to all regions, because of variations as observed by [15] in culture, diet, heredity, climate and other geographical conditions [16]. Also stated that the human body dimension can be affected by cultural, geographical, gender and age factor [17].

Limitation of this study being a retrospective study, minimal bias can be introduce hence prospective study is recommended and also abnormal radiographs either due to fractures or bone diseases as well as normal radiographs of individuals less than 18 years of age were excluded from the measurements, because the study focused on normal adult Nigerians.

4. CONCLUSION

The result of the present study showed that, parameters of APL of talus were all greater in males than in females ($p<0.001$). It was also observed that the APL changed with age, and the changes differ significantly in some age groups. ISDs were found to be greater than 100. This showed that male had higher values over their female counterparts of the same age group. Hence the study of bones morphometry is useful from region to region and country to country, because of these numerous variations that will lead to sex determination. Further work on the talus is required on the southern and other parts of Nigeria and this may be the reason why population specific standards must be developed for sex differentiation in Nigeria.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All authors hereby declare that all radiographs and measurement protocol have been examined and approved by the ethical committee of the University of Maiduguri Teaching Hospital (UMTH) and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Torres B. Population and sex determination based on measurements of the talus. Journal of Biological Anthropology. 2010;2:1.
2. Bidmos M, Dayal M, Asala S. Sex determination from the talus of South African Whites by discriminate function analysis. The American Journal of Forensic Medicine and Pathology. 2003; 24(4):322-328.
3. Davivongs V. The pelvic girdle of the Australian aborigines; sex difference and sex determination. American Journal of Physical Anthropology. 1963;21:443-445.
4. Jit I, Singh S. Sexing of the adult clavicle. Indian Journal of Medical Research.1966; 54:551-571.
5. Singh S, Gangrade K. Sexing of adult clavicle verification and applicability of demarking point. Journal of Indian Academy of Forensic Science. 1968;7:20-30.
6. Singh P, Singh S. Identification of sex from the humerus. Indian Journal of Medical Research. 1972;60:1061-1066.
7. Ari I, Kafa M. Bone length estimation of calcaneus and talus. Coll. Antropol. 2009; 33(2):613-618.
8. Kumar A, Tyagi A, Aggarwal N. Sex determination by morphology of talus bone. Journal of Forensic Medicine and Toxicology. 2008;25:1.
9. Kafa M, Liker M, Liknur A. Bone length estimation and population specific feature of talus of the late Byzantine. Forensic Science International. 2009;2:613-618.
10. In Stat 3 Graph pad. Graphpad software, inc. San Diego California USA; 2003.
11. Harma A, Karakaş HM. Determination of sex from the femur in anatolian caucasians: A digital radiological study. J Forensic Legal Med. 2007;14:190-194.
12. Sarrafin S, Dato H, Jit P. Anatomy of the foot and ankle, discriptive, topography, functional. 2nd ed. Philadelphia; Lippincott. 1993;412-420.
13. Oygulu O, Wafa M, Ragaa M. Pelvic girdle assessment: sex determination from skeletal remains of Indian population. Forensic Science International. 2007; 125:134-136.
14. Kipper G. Determination of sex from femora. Forensic Sci. International. 2002; 113:315-321.
15. Steele D. The estimation of sex on the basis of the talus and calcaneus. American Journal of Physical Anthropology. 2005; 45:581-588.
16. Asala SA, Mbajiorgu FE, Papandro BA. A comparative study of femoral head diameters and sex differentiation in Nigerians. Acta Anatomica. 1998;162:232-237.
17. Ryan S, Michelle N, Stephen E. Anatomy for diagnostic imaging. 2nd ed. Toroto. 2005;609-615.
18. Marin V, Jelena D, Zeljko D, Dair M. Determination of sex by discriminant function analysis of mandibles from two croatian archaeological sites. Acta Stonatology of Croatia. 2006;40(3):263-277.

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