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Estimation of Sex from the Osteometric Measurements of the Femur in a Contemporary Sri Lankan Population

Estimación del Sexo a Partir de las Medidas Osteométricas del Fémur en una Población Contemporánea de Sri Lanka

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SUMMARY: Sex estimation from human skeletal remains is of vital importance in the buildup of a biological profile of an individual in medico-legal and bioarchaeological studies. The present study is focused on the estimation of sex from osteometric measurements of the complete femur and its fragmentary parts, and the development of a web based application related to this. Fifteen osteometric measurements were taken from 78 dry cadaveric femurs from the Faculty of Medicine, University of Kelaniya. Using R software, linear discriminant analysis and logistic regression methods were applied to build classification models with the help of the application of a stepwise procedure, to identify the best combination of measurements to estimate the sex of the femur. A cross-validation method was applied to estimate the predictive accuracy of each model. Since the linear discriminant analysis model gave more predictive accuracy than the regression model, we suggest using linear discriminant analysis to estimate the sex using osteometric measurements of the femur. From the whole femur measurements, a formula to determine sex was developed with highest total accuracy of 83 % using four parameters; epicondylar breadth, anteroposterior mid-shaft diameter, bi-trochanter length, and maximum shaft diameter. Similarly, measurements of transverse head diameter and bi-trochanter length with a total accuracy of 76 % for the proximal part of the femur, measurements of anteroposterior mid-shaft diameter with a total accuracy of 77 % for the mid-shaft, and measurements of epicondylar breadth and maximum length of the lateral condyle with a total accuracy of 70 % for the distal part of the femur were identified as significant discriminants to determine sex, and formulae were written accordingly. Average accuracy ranged from 83 % to 70 %, with male accuracy slightly higher than that of females. A web application to estimate the sex of femur using these formulae was developed and this will be of great importance for forensic medicine and bio-archaeological research in Sri Lanka.

KEY WORDS: Femur, osteometric measurements, sex, Sri Lanka, long bone.

INTRODUCTION

Estimation of sex is a committed step in human skeletal remains analysis and it is normally approached by visual inspection of morphological traits of bones. Since the pelvis and skull bones show high sexual dimorphism, they are in the front line of sexing the skeleton with nearly 98 % predictive accuracy (Leong, 2006). The rest of the 2 % accounts for long bones and this has been strengthened by the research finding that several postcranial elements can outperform skull dimensions in their accuracy to determine sex (Spradley & Jantz, 2011). Among the long bones, the femur which is the strongest bone of the body has commonly been tapped as a site for sex determination. However, not all forensic cases or bioarchaeological contexts provide the luxury of a complete femur due to the operation of taphonomic processes on decease individual. In such cases, it might be difficult that visual assessment of the femur can yield correct sex determination. This has led to exploring the possibility of using the metrical analysis of bone and the revolution of such bone metric analysis has happened with the discovery of the discriminant function statistics (Fisher, 1936). The univariate and multivariate analyses had been applied to well-preserved femurs as well as poorly preserved skeletal remains by several researchers (Wu, 1989; Holliday & Falsetti, 1999).

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It is commonly accepted that skeletal biology of one population is different from another. Therefore, standards for skeletal identification varies among different populations, and that the standards for one population may not be used for another population. Due to this reason population-specific standards have been developed for most populations such as Indians, Chinese, Thai, Americans, Italians, Europeans, and South Africans (Wu, 1989; Trancho *et al*., 1997; King *et al*., 1998; Holliday & Falsetti, 1999; Asala, 2001; Cavazzuti *et al*., 2019). However, such standards are not available to the Sri Lankan population. Most importantly, Sri Lanka has yielded the earliest skeletal evidence of anatomically modern Homo sapiens (37,000 B.P.) in the South Asian region with the Asian best skeletal record sequence which spans a variety of time horizons; Mesolithic, Protohistoric, and historic periods (Kennedy, 1993). Unfortunately, the fragmented nature of all these bones limits the estimation of sex which is abasic feature of biological information. Therefore, in order to fulfill this lacuna, the present study aimed to establish the Sri Lankan population-specific formulae to estimate sex from the complete femur as well as its fragmentary parts, and to develop a web application to estimate sex once the combinations of femur measurements are entered.

MATERIAL AND METHODO

The analyzed sample consists of 78 dry femurs (48 males and 30 females) from the Department of Anatomy and the Department of Forensic Medicine at the University of Kelaniya, Sri Lanka. These subjected femurs were from donated cadavers and the written consent had granted for teaching and research purposes when the cadaver was donated to the Faculty of Medicine by the next kin. The age range for samples was 28 to 86 years old. The femurs contained cortical bone deterioration, severe degenerative changes, or signs of traumatic defects during life were excluded from the study.

A total of 15 measurements were recorded directly on each femur and the descriptions of the measurements were given in Table I and Figure 1. The measurements were taken using standard anthropometric instruments; calibrated osteometric board, a digital vernier caliper, and measuring tape.

Statistical analyses were performed using R statistical software (R Core Team, 2020). The descriptive statistics of the data by each sex is obtained and they were standardized prior to the analysis. Sex estimation was carried out by considering several combinations of variables under the following parts of the femur (Please refer to the Table I for the denotation of the abbreviations).

A. Whole femur: ML, BCL, THD, VHD, TL, BTL, MSC, AP-MSD, T-MSD, Mx-SD, Mn-SD, EB, ML-NC, ML-LC
B. Proximal end: THD, VHD, TL, BTL
C. Shaft: MSC, AP-MSD, T-MSD, Mx-SD, Mn-SD
D. Distal end: EB, ML-NC, ML-LC

The differences between male and female femur dimensions were assessed using Analysis of Variance (ANOVA). Multivariate Analysis of Variance (MANOVA) was carried out to investigate the differences between the sex on the linear combination of the continuous predictor variables. The selected variables were subjected to Linear discriminant analysis (LDA) and Logistic regression (LR) to build separate formulae to determine sex from the

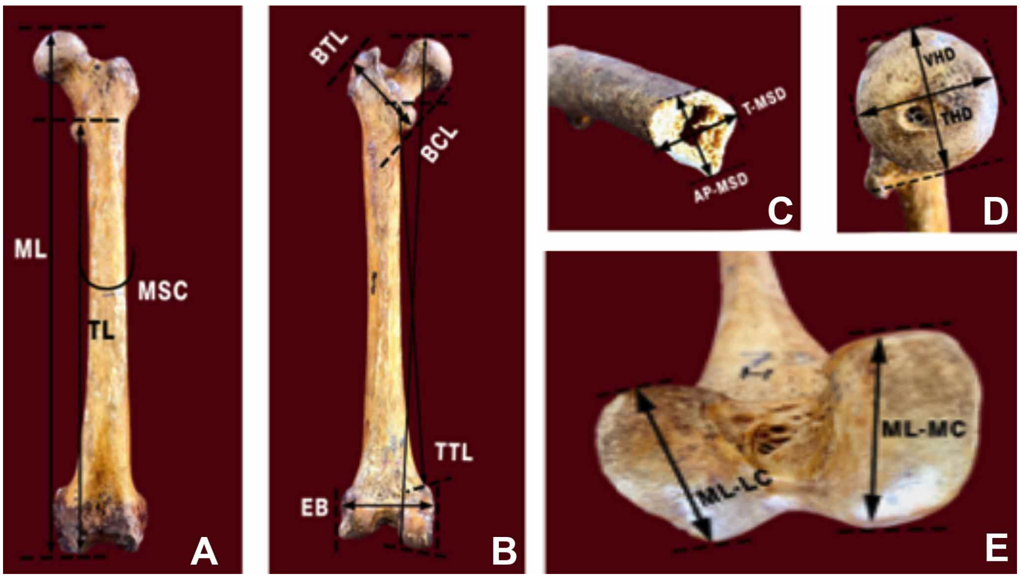

Fig. 1. The femur measurements from different views: A-Anterior surface of the left femur, B-posterior surface of the left femur, C- Mid-shaft cross section of the femur, D- Medial view of the head of femur and E- Inferior view of distal part of the femur (Please refer to the Table I for the denotation of the abbreviations).

measurements of whole femur as well as fragments of femur. To identify the best variable combination on biological sex determination, the stepwise method has been used. We considered both LDA and LR to predict biological sex and compare the accuracy of fitted models with a "leave-one-out" Cross Validation. Ten femurs, which included 5 females and 5 males, from the original sample were used for testing the observer error. The intra-and inter-observer errors were analyzed by the technical error of measurement (TEM) and relative technical error of measurement (rTEM). Assessment of internal consistency of the femur measurements was done using coefficient of reliability (R). The web application to estimate sex once entered the combinations of femur measurements was written using JavaScript language.

Table I. Definition of osteometric measurements of femur used in the study.

No	Femur measurement	Abbreviation	Definition
1	Maximum length	ML	Distance from the highest point on the head of the femur to the lowest point on the distal condyles
2	Bi-condylar length	BCL	Distance from the highest point on the head to a plane drawn along the lower surfaces of the distal condyles
3	Epicondylar breadth	EB	Distance between the two most laterally projecting points on the medial and lateral epicondyles
4	Transverse head diameter	THD	Maximum diameter of the femoral head, measured perpendicular to the long axis of the femoral diaphysis, with the femur held vertically
5	Vertical head diameter	VHD	Superoinferior diameter of the femoral head, measured parallel to the long axis of the femoral diaphysis, with the femur held vertically
6	Trochantero-condylar length	TL	Distance between the medial condyle to the tip of the upper margin of the lesser trochanter
7	Mid-shaft circumference	MSC	Circumference measured at the level of the mid-shaft diameters
8	Anteroposterior mid-shaft diameter	AP-MSD	Distance between anterior and posterior surfaces measured approximately at the midpoint of the diaphysis
9	Transverse mid-shaft diameter	T-MSD	Distance between the medial and lateral surfaces at the mid-shaft, measured perpendicular to the anterior-posterior diameter
10	Bi-trochanter length	BTL	Distance measured from the greater trochanter to the lesser trochanter
11	Maximum length of the medial condyle	ML-MC	Maximum distance between the anterior and posterior points measured on the articular surface of the medial condyle
12	Maximum length of the lateral condyle	ML-LC	Maximum distance between the anterior and posterior points measured on the articular surface of the lateral condyle
13	Maximum shaft diameter	Mx-SD	Maximum distance between the anterior and posterior margins of the shaft, wherever it occurs
14	Minimum shaft diameter	Mn-SD	Minimum distance between the anterior and posterior margins of the shaft, wherever it occurs
15	Trochanteric tubercular length	TTL	Vertical distance between the upper part of the lesser trochanter and the adductor tubercle

RESULTS

The assessed measurement errors of femur given in Table II. The obtained values for the intraobserver range of rTEM are lower than the acceptable limit of 1.5 % and coefficient of reliability (R) of all parameters are high with 0.96 - 0.99. Similarly, interobserver range of rTEM of all parameters are acceptable (rTEM ≤ 2.0 %) with the range of R value is 0.95 - 0.99.

From the descriptive analysis, it was evident that for all the variables, male values are higher than the female values in mean, with the males generally showing smaller standard deviation. Numerical descriptive statistics with the means and standard deviations for each variable are given in Table III. Mean differences between the male and female bones under each osteometric measurement have been analyzed using one-way ANOVA. The variables VHD and T-MSD were removed from the further analysis since they do not show significant differences among sex due to high p-values as shown in Table III.

A high linear correlation was observed between the two whole lengths of the femur defined by ML and BCL with a 0.99 correlation coefficient. Therefore, BCL was not considered in the model building since ML is easier to measure. The greater discriminatory ability of the linear function of selected 12 osteometric variables in determining the sex of the femur was confirmed by the small value of Wilks' lambda of 0.486 given by the MANOVA test.

Table IV shows the significant results of the stepwise discriminant function for the whole femur and the fragmented parts. Wilks' lambda calculates the percentage contribution of each variable and determines the order in which variables enter the function. For the whole femur, only four (AP-MSD, EB, BTL, Mx-SD) of the twelve femur variables were significant, whereas AP-MSD was selected as the variable with the highest discriminant power. Similarly, for the fragmented parts of the femur (proximal end, mid-shaft and distal end) variables identified as significant in determining sex are included in Table IV.

Classification results generated from leave-one-out cross validation are shown in Table IV for the whole femur and the fragmented parts in terms of total accuracy, female accuracy and male accuracy. They were used to validate the predictive accuracy of the models in determining biological sex. Coefficients and classification boundaries (average of two centroids of scores) are provided for the whole bone and fragmented parts in Table V.

Table III. Descriptive statistics of the osteometric measurements of femur (cm).

	Female (n=30)		Male (n=48)		
Variables	Mean	SD	Mean	SD	P value
ML	42.90	2.61	45.04	1.96	0.0001
BCL	42.37	2.64	44.57	1.94	0.0001
EB	7.22	0.38	7.73	0.37	<0.0001
THD	4.08	0.28	4.30	0.26	0.0006
VHD	4.13	0.67	4.19	0.28	0.5058
TL	38.49	3.70	41.37	3.35	0.0006
MSC	7.89	1.12	8.66	0.49	<0.0001
AP-MSD	2.60	0.24	2.91	0.19	0.0000
T-MSD	2.62	0.94	2.68	0.24	0.6550
BTL	6.62	0.95	7.46	0.47	<0.0001
ML-MC	5.19	0.35	5.50	0.35	0.0003
ML-LC	5.65	0.34	6.05	0.32	0.0000
Mx-SD	2.77	0.24	2.95	0.22	0.0004
Mn-SD	2.37	0.19	2.57	0.20	0.0000
TTL	32.43	2.21	34.03	1.99	0.0015

Table II. Technical error of measurement (mm) and coefficient of reliability of intra and inter-observer error.

Measurement	Intra-observer error			Inter observer error		
Maximum length	0.45	1.03	0.98	0.41	0.94	0.98
Bi-condylar length	0.41	0.95	0.98	0.40	0.93	0.99
Epicondylar breadth	0.07	0.93	0.98	0.06	0.83	0.99
Transverse head diameter	0.04	0.98	0.99	0.05	1.20	0.98
Vertical head diameter	0.06	1.50	0.96	0.04	1.02	0.98
Trochantero-condylar length	0.62	1.50	0.98	0.39	0.94	0.99
Mid-shaft circumference	0.10	1.22	0.96	0.11	1.36	0.95
Anteroposterior mid-shaft diameter	0.05	1.50	0.98	0.05	1.79	0.98
Transverse mid-shaft diameter	0.03	1.07	0.99	0.04	1.64	0.96
Bi-trochanter length	0.09	1.18	0.98	0.07	0.99	0.98
Maximum length of the medial condyle	0.07	1.40	0.96	0.05	0.94	0.98
Maximum length of the lateral condyle	0.06	0.99	0.97	0.03	0.51	0.99
Maximum shaft diameter	0.04	1.38	0.98	0.05	1.90	0.97
Minimum shaft diameter	0.04	1.50	0.97	0.04	1.58	0.97
Trochanteric tubercular length	0.46	1.38	0.97	0.55	1.64	0.96

Table IV. Stepwise linear discriminant analysis of the osteometric measurements of femur.

Variables of femur	Wilks lambda	F statistics overall	P value overall	Total accuracy	Female Accuracy	Male Accuracy
Whole femur						
AP-MSD	0.6441	42.0032	<0.0001			
EB	0.5541	30.1771	<0.0001	0.8333	0.7000	0.9167
BTL	0.5294	21.9291	<0.0001			
Mx-SD	0.5110	17.4644	<0.0001			
Proximal end						
BTL	0.7360	27.2651	<0.0001	0.7564	0.4667	0.9375
THD	0.7081	15.4550	<0.0001			
Shaft						
AP-MSD	0.6441	42.0032	<0.0001	0.7692	0.6000	0.8750
Distal end						
EB	0.7006	32.4750	<0.0001	0.7051	0.6207	0.7551
ML-LC	0.6733	18.1935	<0.0001			

Table V. Linear discriminant analysis of the osteometric measurements of femur.

Variables of femur	Coefficients	Mean observation values for variables in each pre-defined group		Classification boundary (<males)
		Female	*Male*	
Whole femur				
EB	0.7363	-0.6877	0.4298	-0.2290
AP-MSD	0.8647	-0.7498	0.4686	
BTL	0.4000	-0.6458	0.4036	
Mx-SD	-0.3890	-0.4925	0.3078	
Proximal end				
THD	0.4069	-0.4748	0.2967	-0.1503
BTL	0.9421	-0.6458	0.4036	
Shaft				
AP-MSD	1.2379	-0.7498	0.4686	-0.1740
Distal end				
EB	0.7657	-0.6877	0.4298	-0.1631
ML-LC	0.5265	-0.6518	0.4074	

The generated formula for the calculation of the discriminant score for each bone using the coefficients given below. Each variable should be standardized using its empirical mean and standard deviation before applying the equations to estimate the discriminant score.

$$standardized\ EB = EB_z = \frac{EB - mean(EB)}{standard\ deviation(EB)}$$

The **Whole femur** classification score can be calculated as follows,

Classification score = $0.7363EB_Z + 0.8647APMSD_Z + 0.4BTL_Z - 0.3890MxSD_Z$

If the resulted classification score from formula (1) is strictly less than -0.2290, then the bone is classified as female.

For the **proximal end of femur**,

Classification score = $0.4069THD_Z + 0.9421BTL_Z$

If the resulted classification score from formula (2) is strictly less than -0.1503, then the bone is classified as female.

For the **mid shaft section of femur**,

Classification score = $1.2379APMSD_Z$

If the resulted classification score from formula (2) is strictly less than -0.1740, then the bone is classified as female.

For the **distal end of femur**,

Classification score = $0.7657EB_Z + 0.5265MLCL_Z$

If the resulted classification score from formula (2) is strictly less than -0.1631, then the bone is classified as female.

The performance of the whole bone model in classifying a bone to each sex is based on the classification boundary. The accuracy of the classification is higher when the discriminant score lies far away from the classification boundary.

Table VI shows the statistically significant variables to determine sex using logistic regression method. Stepwise procedure selected the best combination of variables. For the whole femur, only three (AP-MSD, EB, Mx-SD) of the twelve femur variables were significant, where AP-MSD was selected as the best variable which increases the odds of a bone to be classified as a male. Similarly, for the fragmented parts of the femur (proximal end, mid shaft and distal end) variables identified as significant in estimating sex are included in Table VI. Using the same validation procedure, classification results of logistic models were obtained for the whole femur and the fragmented portions (Table VI). The entire femur yielded the highest overall accuracy. Upper portion variables fared best in determining male, whereas the full femur model performed best in determining female.

Using the estimated coefficient of the logistic regression model, probability of the bone belonging to a male is estimated as given in the below forms. Where P (Male) is the probability of a bone is belonging to a male. If the estimated probability is > 0.5 then the femur is classified as a male femur.

For the **Whole femur**

$$P(Male)= \frac{1}{e^{-(0.9109 + 1.7220EB_z + 2.2357APMSD_z - 0.9453MxSD_z)} + 1}$$

For the **proximal end of femur**

$$P(Male) = \frac{1}{e^{-(0.4739 + 2.2241BTL_z)} + 1}$$

For the **mid shaft section of femur**

$$P(Male) = \frac{1}{e^{-(0.6902 + 2.0570APMSD_z)} + 1}$$

For the **distal end of femur**

$$P(Male) = \frac{1}{e^{-(0.7181 + 1.0285EB_z + 0.8437MLLC_z)} + 1}$$

The web application developed to estimate the sex once the combinations of femur measurements are entered can be accessed via https://www.sofsysit.com/webbone/.

DISCUSSION

The human populations are different from one geographic location to another in skeletal biology. These differences are mainly depending on their gene pool, living environment and as well as the interactions between those two factors. Therefore, in forensic and physical anthropological studies, it is commonly accepted that standards for human skeletal identification needs more population-specific data. When sexing the human skeleton, the choice of priority goes for morphological features of the pelvic girdle and skull followed by the long bones. In the case of very fragmentary bones, it is still possible to determine the sex of an individual by the molecular analysis and the osteometric measurements. With the advancement of technology, the molecular analysis stays at the frontline over the osteometic measurements. But unfortunately, it was

Table VI. Predictive accuracy for the logistic regression models.

Variables of femur	Estimate	*p.value*	*Total accuracy*	*Female accuracy*	*Male accuracy*
Whole femur					
(Intercept)	0.9109	0.0140	0.8205	0.7667	0.8542
EB	1.7220	0.0025			
AP-MSD	2.2357	0.0005			
Mx-SD	-0.9453	0.0936			
Proximal end					
(Intercept)	0.4739	0.0980	0.7564	0.5667	0.8750
BTL	2.2241	0.0001			
Shaft					
(Intercept)	0.6902	0.0247	0.7692	0.6333	0.8542
AP-MSD	2.0570	0.0000			
Distal end					
(Intercept)	0.7181	0.0185	0.6923	0.5667	0.7708
EB	1.0285	0.0268			
ML-LC	0.8437	0.0814			

evident that deoxyribonucleic acid (DNA) is not well preserved in prehistoric human skeletal remains from Sri Lankan context due to persistent climatic conditions (Reed *et al*., 2003). Therefore, the present study is conducted to obtain a Sri Lankan population-specific formula for estimation of the sex using osteometric measurements of femur.

By combining significant 12 osteometric measurements, we were able to find models with higher accuracy to estimate the sex of the whole femur as well as the fragments of the femur (proximal part, mid-shaft, and distal part) using Linear Discriminant Analysis (LDA) and Logistic Regression (LR). For the whole femur model, it was evident that the LDA formula with 4 osteometric measurements (total accuracy -83 %) is better than the LR formula with 3 osteometric measurements (total accuracy -82 %). The LDA gave higher male accuracy of 92 % when compared to 85 % male accuracy of LR. However, the female accuracy of the LR (77 %) is slightly higher than the LDA (70 %).

For the proximal part of the femur, measurements of BTL and THD were included in the LDA model with 75 % total accuracy whereas LR gave the same accuracy with only BTL. Interestingly, this part of the femur indicates 93 % of male prediction accuracy in LDA. This is the highest accuracy percentage for any given measurement of the femur in the current study. However, female accuracy is lower when compared to male accuracy in both models. Similarly, for the mid-shaft of the femur, only AP-MSD with 76 % of total accuracy was identified by both LDA and LR. Male and female accuracies are similar from both methods for the mid-shaft of the femur. For the distal part of the femur, both measurements of EB and ML-LC were identified as the variables to estimate sex using LDA with a total accuracy of 70 %, and LR with a total accuracy of 69 %. In this part, male accuracy prediction from both LDA and LR is pretty similar when compared to female accuracy.

Considering the whole femur and all the fragmented parts, male accuracy is higher in LDA than LR. Similarly, female accuracy is higher in LDA when compare to LR when considering the lower part of the femur.

The skeletons of males, generally, are noticeably larger and more robust than those of females. As a part of the appendicular skeleton, long bones also follow this concept. But a complicating feature is that sexual dimorphism, the difference in size and robusticity, varies from population to population; American blacks and American whites have a higher degree of sexual dimorphism whereas it is less pronounced among Southeast Asian populations. From our study, it is evident that the most dimorphic part, related to the fragmented femur for the Sri Lankan population is the shaft. This is in contrast to the finding of Chinese people have the distal breadth as the most dimorphic part whereas, American whites and blacks femoral head diameter is the most dimorphic (Is¸can & Shihai, 1995; Asala, 2001). Interestingly, epicondylar breadth measurement gives lower accuracy for the Sri Lankan population whereas it gives high accuracy for Africans of European descent (Bidmos, 2008). In a study from Central India, the maximum diameter of the femur head gave the best accuracy (Soni *et al*., 2010). Another study in North India indicates that the epicondylar breadth, proximal breadth, and antero-posterior diameter of the lateral condyle were the most discriminating variables (Srivastava *et al*., 2012). These findings highlight the need for having population-specific data in biological sex determination in forensic and anthropological studies, and the current study provides such preliminary data for Sri Lankan population.

The antero-posterior diameter of the femoral shaft is directly related to the muscle attachment to the bone. Several strong muscles of the posterior compartment of thigh make their insertion at the linea aspera, which is the area of measurement. Males generally use their muscles more powerfully due to heavy body weight and prominent insertion areas of the femur. Our results are compatible with the finding that the circumference and width dimensions of the femur contribute more to the differences between the sex than do length measurements (Macho, 1990; Nieves *et al*., 2005). Similar results are reported from Japanese skeletal materials and American whites (Trotter & Gleser, 1952; Sakaue, 2004). However, American blacks indicated that the length measurements contribute more to sexual dimorphism than width and circumference measurements (Trotter & Gleser, 1952). Therefore, researchers should continue their efforts to set osteometric measurements for diverse populations in the world in order to develop better identification techniques for the bio- archaeological and forensic arena.

The developed web application to estimate the sex from femur osteometric measurements will be really useful and time saving for researchers. Moreover, according to the available data, this is the very first study that created such a web application in skeletal remain analysis. Hence, our research findings will be an eye-opener in the forensic and bio-archaeological research arena all over the world.

CONCLUSION

This study indicates that femur measurements are a useful tool in the estimation of sex in human skeletal remains found from the archaeological and forensic context in Sri Lanka. A linear discriminant analysis model over the regression model is suggested to estimate the sex using osteometric measurements of the fragmentary and complete femur. For a fairly completed femur, linear discriminant function analysis of four femoral measurements (Anteroposterior mid-shaft diameter, epicondylar breadth, bi-trochanter length, and maximum shaft diameter) provides higher accuracy of sex determination. However, for fragmented proximal part of the femur indicated the measurements of Transverse head diameter and bi-trochanter length, whereas the fragmented distal part of the femur suggested the measurements of epicondylar breadth and the maximum length of the lateral condyle. The highest discriminating power of sex estimation from femur is gained by the measurement of anteroposterior mid-shaft diameter which is ideal for sex estimation when only the shaft of the femur is available.

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RESUMEN: La estimación del sexo a partir de restos óseos humanos en los estudios médico-legales y bioarqueológicos es de vital importancia en la construcción de un perfil biológico de un individuo. El objetivo de este estudio fue la estimación del sexo a partir de medidas osteométricas del fémur completo y sus partes fragmentarias, y el desarrollo de una aplicación web relacionada con esto. Se tomaron quince medidas osteométricas de 78 fémures cadavéricos secos de la Facultad de Medicina de la Universidad de Kelaniya. Utilizando el software R, se aplicaron métodos de análisis discriminante lineal y regresión logística para construir modelos de clasificación con la aplicación de un procedimiento por pasos, para identificar la mejor combinación de medidas y estimar el sexo a partir del fémur. Se aplicó un método de validación cruzada para estimar la precisión predictiva de cada modelo. Dado que el modelo de análisis discriminante lineal proporcionó una mayor precisión predictiva que el modelo de regresión, sugerimos su utilización para estimar el sexo mediante mediciones osteométricas del fémur. A partir de las mediciones del fémur completo, se desarrolló una fórmula para determinar el sexo con la mayor precisión total del 83 % utilizando cuatro parámetros; anchura del epicóndilo, diámetro anteroposterior del tercio medio de la diáfisis, longitud bitrocánter y diámetro máximo de la diáfisis. De manera similar, utilizamos las mediciones del diámetro transversal de la cabeza del fémur y la longitud del bitrocánter con una precisión del 76 % para la parte proximal del hueso, las mediciones del diámetro anteroposterior del tercio medio de la diáfisis se obtuvo con una precisión del 77 %. El ancho del epicóndilo y la longitud máxima del cóndilo lateral con una precisión del 70 % para la parte distal del fémur se identificaron como discriminantes significativos para determinar el sexo y se escribieron fórmulas. La precisión promedio osciló entre el 83 % y el 70 %, siendo la precisión en los hombres ligeramente superior al de las mujeres. Se desarrolló una aplicación web para estimar el sexo del fémur utilizando estas fórmulas y creemos será importante para la medicina forense y la investigación bioarqueológica en Sri Lanka.

PALABRAS CLAVE: Fémur; Medidas osteométricas; Sexo; Sri Lanka; Hueso largo.

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