Sex Determination From the Bicondylar Width of the Femur: A Nepalese Study Using Digital X-ray Images

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ABSTRACT

Background

One of the important components of forensic identification is sex determination. The prediction of sex becomes easy with a complete skeleton. The problem arises with mutilated and incomplete skeletal remains. The skull and pelvis are preferred for sex prediction, but not uncommonly, long bones are brought for forensic examination. The femur out stands as the most dimorphic long bone. The literature on sex determination from the femur in different population groups is in abundance. The forensic anthropology literature suggests that longitudinal dimensions are often less discriminating than the breadth and circumference of long bones. Many researchers have suggested that the bicondylar width of the femur is the most dimorphic dimension.

Objective

To evaluate the sexing potential of the bicondylar width of the femur in the Nepalese population using digital X-ray images.

Method

A sample of 200 digital X-ray images of the knee belonging to 100 males and 100 females was used to measure the bicondylar width of the right femur. These digital X-ray images were those of Nepalese patients who visited the Department of Radiology at the affiliate hospital of Kathmandu University School of Medical Sciences, Dhulikhel, Nepal for diagnostic and treatment purposes.

Result

The resent study reveals a statistically significant difference for the bicondylar width of the femur between males and females. A regression equation was derived with sectioning point 77.84. Using the regression equation the prediction of sex was 68% with an overlapping of 32%. Having a low prediction in comparison to other studies in different populations, 95% confidence interval for the mean was used to get a range of measurements of the bicondylar width for males and females. The range stated in the present study is 79.47 mm to 82.20 mm for males and 73.75 mm to 75.93 mm for females.

Conclusion

The bicondylar width of the femur cannot be individually recommended for sex determination in the Nepalese population, but could be considered if analyzed along with the other morphometric traits for sex determination.

KEY WORDS

Bicondylar width, dimorphism, femur, forensic anthropology, identification, sex determination

INTRODUCTION

Sex prediction is one of the most important steps in identifying skeletal remains. It is difficult to evaluate sex in cases of fragmented bones. Thus research in this facet of forensic anthropology is imperative. Anthropological data is population specific and has to be renewed at regular intervals to cope up with the temporal change.[1,2]

Determination of sex from the skull and pelvis are the most reliable methods in forensic anthropology.[3] However, sex determination from other parts of the skeleton, especially long bones, is essential when the skull or pelvis are unavailable. Long bones including the femur are frequently found and brought for forensic examination. Several studies have been conducted in the past where sex determination has been done from long bones.[4-21] Steyn and Iscan investigated femur from a White South African population; Iscan, Shihai and Liu in Chinese population.[4-6] DiBennardo and Taylor tested a method previously developed by Black in a sample of femur from North American Whites.[7,8] Schulter Ellis et al. in their investigations on pelvic dimensions mention data for the femoral head diameter in North American Blacks, Eskimos, Indians and Whites.[9-11] Leopold cites own measurements of length and vertical head diameter in German individuals.[12,13] Pons took femoral measurements in a Portuguese population.[14] Several parts of the femur have been studied for this goal.[14]

Many possible femoral measurements can be taken, out of which bicondylar width is routinely considered to be used for sexing individual. The study of an isolated measurement like the bicondylar breadth is of interest in cases of badly preserved or fragmentary remains. Previous research has indicated that, sex determination from long bones, longitudinal distances such as lengths are often less discriminating than breadth and circumference, which was accepted by Iscan and Ding and also stated that bicondylar breadth is the most dimorphic part of recent Chinese femurs.[4,5] Similar result was obtained in a contemporary Thai population.[16] A study in contemporary German population, sexed 81.4% of cases using bicondylar breadth.[17] A Study done in French population by Alunni-Perret et al. enforced bicondylar width as the most dimorphic part of the femur.[19] The aim of the present study is to evaluate the relevance of sex determination from the isolated measurement of the bicondylar width of the femur in a Nepalese population using digital X-ray images.

METHODS

The present study was approved by the Institutional Review Committee at Kathmandu University School of Medical Sciences, Dhulikhel, Nepal and conducted in accordance with the ethical standards laid down by the Declaration of Helsinki drafted by the World Medical Association. Patients included in this prospective study were randomly selected from those who presented to the Department of Radiology at the affiliate hospital of the aforementioned institute between January 2016 and March 2016. Verbal informed consent for relevant data to be collected for the present study was obtained from 200 patients (100 males and 100 females) who required a knee X-ray for diagnostic purpose during the course of their treatment. The bicondylar width (maximum width between the lateral and medial epicondyles) of the right femur, parallel to the infracondylar plane was measured. To avoid any magnification error the measurement was taken on the console of the digital X-ray in the Department of Radiology. The unit of measurement was in centimeters in the digital X-ray machine which was later converted into millimeters (1 cm = 10 mm). Digital X-ray images showing fractures, congenital abnormality or any pathological condition involving the lower end of the right femur were excluded from the study.

Figure 1. Measurement of the bicondylar width.

The data was entered into Microsoft Excel and analysed using SPSS, version 20, statistical analysis program (SPSS, Inc., Chicago, IL). Sexual dimorphism was tested using Student's t-test and statistical significance (p value) was defined at α=0.05. The independent sample t-test was used to compare the means of males and females and logistic regression analysis was performed to predict the sex from the bicondylar measurement.

The inter-observer and intra-observer errors were tested on the initial 10 digital X-ray images using paired t-test. Statistically significant difference was not observed for the bicondylar width measurements taken by two observers. Statistically significant difference was also not observed for the bicondylar width measurements taken by a single observer wherein the second reading was taken a couple of days after taking the first reading. Further, 200 measurements of the bicondylar width taken by a single observer were only included for statistical analysis in this study.

RESULTS

The present study comprised of a total of 200 digital X-ray images of the right knee joint belonging to 100 males and 100 females of Nepalese origin. The sex and age distribution of the study sample is presented in Table 1.

Table 1. Sex and age distribution of the study sample

Sex	N	Minimum	Maximum	Mean	S.D
Male	100	15	80	44.51	18.431
Female	100	15	82	47.53	14.572

N: Number of cases; S.D: Standard deviation

The descriptive statistics of the bicondylar width in both the sexes are presented in Table 2

Table 2. Descriptive statistics of the bicondylar width of the femur

Sex	N	Minimum	Maximum	Mean	S.D
Male	100	62.70	95.50	80.8400	6.85451
Female	100	60.00	86.30	74.8380	5.49344

N: Number of cases; S.D: Standard deviation

The data was further subjected to independent t test which expressed the t test to be significant (p=0.000), when equal variances assumed and equal variance not assumed {sig (two tailed) 0.000 for equal variance assumed and equal variance not assumed} as detailed in table 3.

Table 3. Independent t test of the data (t-test for equality of means)

Bicondylar width	t	df	Sig. (2-tailed)	Mean difference	Standard error difference
Equal variances assumed	-6.833	198	0.000	-6.00200	0.87842
Equal variances not assumed	-6.833	189.032	0.000	-6.00200	0.87842

The independent t test showed a very high significance (p=0.000), from which a regression equation was derived for sex determination from bicondylar width. The equation has sectioning point 77.84.

Sex = Bicondylar width X 0.154 + (-11.990)

Table 4. Variables in regression equation

	B	SE	Wald	df	Sig.	Exp(B)
Bicondylar width mm	0.154	0.027	31.957	1	0.000	1.166
Constant	-11.990	2.127	31.765	1	0.000	0.000

B: Beta value; SE: Standard error

Table 5. Prediction of sex using regression equation

Sex	Female	Male	Percentage
Female	68	32	68.0
Male	32	68	68.0
Percentage			68.0

With the use of the regression equation the predictability of sex is 68%, with overlapping 32% as detailed in table no 5. The 95% confidence interval for mean is shown in table 6, which states the range for each sex. The ranges stated in the present study are 79.47 mm to 82.20 mm for male; and 73.75 mm to 75.93 mm for females respectively.

Table 6. Range for bicondylar width

95% CI for Mean	Male	Female
Upper bound	82.2001	75.9280
Lower bound	79.4799	73.7480

DISCUSSION

Research related to forensic anthropology in the Nepalese population is limited. Various studies in the field of forensic anthropology have concluded that sex determination is population specific.[1,2] Moreover, recent studies even suggest that sex determination is not only population specific for a region but there may be intra-population variations depending on multiple factors.[16,19] Therefore, it is important to conduct multiple studies on various morphological traits for the purpose of sex determination. Studies have suggested that the pelvis and skull are the best bones for sexing,[1] but due to the nature of forensic investigations, sex determination from other bones is also equally important. Femur is next in line for its sex prediction and should also be subjected to vigorous studies in different populations.

The linear dimensions such as the length of femur are often less discriminating than the breadth and circumference measurements,[7] Iscan and Ding in their study of femur in Chinese population have supported the preexisting findings.[5] Various studies by multiple authors in different population have studied femur for sex prediction and concluded that bicondylar width is a single most important measurement with high accuracy of sex prediction.[15-19] The present study focuses on the sex prediction from bicondylar width also known as epicondylar breadth by some authors. Authors like Steyn, Iscan et al. Taylor and King etc have stated that bicondylar width is the most dimorphic part of the femur.[4,5,7,16] Our study has taken measurements from right femur, as Iscan et al. and Alunni-Perret et al. found no significant difference between right and left femur.[16,19]

The highest accuracy for sex determination using bicondylar width of femur (97.5%) was obtained in Spanish population, study by Trancho et al.[18] In a study by Alunni-Perret et al. in French population, the accuracy of sex prediction was 95.4%.[19] Similarly Iscan and Ding in their study on Chinese femur stated distal epicondylar breadth provided separation (94.9%) and suggested it as the most dimorphic part of the Chinese femur.[5] In a study done on Thai population by King et al. the study had (93.3% accuracy) similar findings as Chinese.[16] Our present study gives a high significant difference (p=0.000) between male and female, with mean 80.84 mm (SD=6.85) for males and 74.84 mm (SD=5.49) for females. With formulation

Table 7. Bicondylar width and its accuracy (descending order) in different populations.

	Male	Female	Accuracy	Sectioning point	Sample size
Spanish study[18]	80.6±2.9	70.8±2.3	**97.5%**	75.7	132
French study[19]	84.3±3.6	74.8±2.5	**95.4%**	79.6	88
Chinese study[5]	80.3±4.2	70.6±3.2	**94.9%**	75.5	87
Thai study[16]	83.7± 4.7	75.4±5.4	**93.3%**	74.8	104
Croatian study[21]	86.7±4.3	75.1±4.1	**91.3%**	_	195
White South African study[4]	84.6±4.6	75.1±3.3	**90.5%**	_	106
Indian study[20]	78.7±4.5	66.8±4.2	**90.3%**	72.7	124
German study[17]	84.0±10	77.0±5.0	**81.4%**	_	170
Present study	80.84±6.85	74.84±5.49	**68.0%**	77.84	200

of regression equation, the sectioning point was 77.84, using this regression equation the prediction of sex was 68% having overlapping 32%. The prediction percentage is the lowest compared to any study till date (Table 7). This reinstates that sex determining features are population specific.

A study in the Indian population by Purkait and Chandra and a study in the western Japanese population by Nakahashi and Nagai had a low sex prediction (90% in each population),[20,22] our study has even lower than these populations. With a low predictability of sex using bicondylar width of femur in our study, range of measurement for male and female was considered using 95% confidence interval (CI) for mean (table 6). The present study suggests the range as 79.47 mm to 82.20 mm for males; and 73.75 mm to 75.93 mm for females in data collected of Nepalese population with 95% accuracy. The bicondylar width falling between 75 mm to 79 mm cannot be sexed with reliable accuracy. Thus implicating that the bicondylar width individually cannot be used for determination of sex in the Nepalese population, but in combination with other morphometric variables it can be used for sex prediction.

CONCLUSION

The bicondylar width of the femur, with its highly significant (p=0.000) difference between male and female cannot be recommended for sex determination in Nepalese population, since the percentage of predictability is less (68%), the overlapping being considerable high (32%). It can be considered if taken along with other morphometric traits for sex determination. However, similar studies are proposed on larger samples and on dry bones to study the sexing potential of the bicondylar width in forensic investigations.

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