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Original Article

Morphometric Analysis of Clavicle Weight for Sex Determination in a Bangladeshi Sample

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Abstract

Background: Gender identification is a difficult task when to do from few bones. In medico-legal situations where accuracy is important, the conventional techniques are subjective and of little use. Hence, this study aimed to do metrical analysis of clavicular weight for the identification gender in a Bangladeshi sample.

Materials and Methods: This quantitative analytical study was performed in the Department of Anatomy, Sylhet MAG Osmani Medical College, Sylhet. There were 60 dry adult human clavicle analyzed, 29 were male and 31 were female clavicle. Initial gender identification was done based on the discriminant function analysis. The weight was measured using a physical balance. Demarking points were calculated by adding and subtracting three standard deviations from the mean value. The SPSS (version 22.0) used to analyze the data. Mean values compared by unpaired t-test, Cohen's d effect size also calculated. The demarking points were further analyzed by Receiver-Operating Characteristic (ROC) Curve analysis to evaluate sensitivity and specificity of the sample. All the statistical tests were performed under 95% confidence interval, a p-value of <0.05 considered as statistically significant.

Results: This study showed the mean weight of right male clavicle was 17.46±4.84gm and in female was 12.85±3.96gm.In contrast, the mean weight of left male's clavicle was 18.91±6.09gm and in female was 12.36±3.35 gm. The mean differences between male and female gender found statistically significant both in right (d = 1.017, 95% CI: 1.171 – 8.049, p = 0.013) and left (d = 1.275, 95% CI: 2.985 – 10.115, p = <0.001) clavicle. The demarking points for the right clavicle were >24.73 in male and <2.94 in female, and for the left clavicle were >22.41 in male and <0.64 in female gender. ROC analysis showed that the area under curve (AUC) for right clavicle was 0.642 (95% CI: 0.433 – 0.851) and left clavicle was 0.526 (95% CI: 0.313 – 0.739). There were wide range of variation in sensitivity and specificity found between the demarking points between male and female gender in this study sample.

Conclusion: The results of this study agree with the opinion that weight of the clavicle can be used as a tool for gender identification. However, recent advancement of statistical analysis showed necessity of reconsideration of the older method of gender identification.

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Introduction:

Skeletal remains are crucial for proving the subject's identification.

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Especially in determining the sex of an unknown decomposed body, itis one of the most crucial duties in medico-legal cases[1]. Apart from forensic sciences, the accurate estimation of the sex of a skeletonized human is important to physical Anthropologists, Bio-archaeologists, and Anatomists[2].The most widely used statistical model for determining sex, discriminate function analysis, was created recently, which inspired many forensic scientists to evaluate their anthropometric data[3]. The primary criteria (big fours) of identifications are age, stature, sex and race of the person. While age, size and race each provide points within a large range of variables; determining a person's sex is statistically the most relevant criterion as it quickly excludes around half of the population[4,5]. When tackling the difference in skeletal material between the sexes, the clavicle is considered to be a crucial bone[6]. Skeletal remains such as the skull, pelvis, upper and long lower limb bones, sternum, patella and clavicle have been used for the identification of unknown individuals[7]. Sex determination is comparatively easy, if the whole skeleton is available for examination. In many situations, full skeleton may not be available except few bones or only segment of bones may available. In that case, it is important to identify sex from skeletal remains. The accuracy of sexing adult skeletal remains, according to Krogman, is as follows: 100% for the entire skeleton, 95% for the pelvis alone, 90% for the skull alone, 98% for the pelvis plus skull, and 80% for the long bone alone[8].

The clavicle is the first bone in the body to ossify and is the only long bone that lies horizontally in the body[7]. It is a long bone that is comparatively resistant to environmental degradation and has been proposed as a reliable bone to determine sex[9].The anatomical characteristics of the male and female clavicles differed. It came to light that the female clavicle was smoother, thinner, shorter, and less curled than the male[7].While, men's bones are thicker than women's, and their muscular features are more noticeable[10].However, human clavicle showed widespread variability that depends on sex, activity, laterality and occupation. Due to its extended growth period, it may possess additional features for identification, particularly for the age and sex[11].

Though earlier studies mostly showed significant sex determination based on bones other than the clavicle, it still remains underreported in literature as a potential estimator of identity of an unknown skeleton. Studies have been done in India on clavicles using their mid-clavicular circumference, length, weight and found that mid-clavicular circumference as a best criterion for identifying the sex[12]. In southern part of Karnataka, a study was done by discriminate functional analysis (DFA) on the clavicles by using their mid-clavicular circumference, length and weight as the parameters for sex determination and found out that length and weight are the best criteria for deciding the sex of the clavicle[13]. Shobha et al. gave us the concept of demarking point (3±SD) which was found extremely useful and provide almost 100% specificity in sex determination. Demarking point can be calculated by using the formula DP=Mean±3SD, where mean+3SD gives maximum limit and mean -3SD gives minimum limit[14].

The clavicle is thought to be an essential bone for addressing skeletal disparities between sexes. Identification of individual from decomposed body, severely burned body, also in forensic anthropology is important. However, few studies reported sex identification using clavicular weight in their studies, result varied with different ethnicity. There is a lack of data on morphometric data of clavicle and its usefulness for the sex identification Bangladesh. Hence, this study primarily aimed to establish population-specific demarking points for clavicle weight used as a tool for identification of sex.

Methods

This quantitative analytical study was conducted in the Department of Anatomy, Sylhet MAG Osmani Medical College, from July 2018 to June 2019. A total of 60 dry adult human clavicles (29 right-sided and 31 left-sided) were included in the study. The sample size was based on the availability of specimens fulfilling inclusion criteria during the study period. Although a formal power analysis was not performed, similar morphometric earlier studies

have used comparable sample sizes ranging from 40 to 80 clavicles, which believed to produce statistically significant and clinically meaningful results. Therefore, the sample size was considered adequate for initial population-specific morphometric assessment. Purposive sampling was used to select well-preserved, fully ossified clavicles from the local population. All clavicles were dry, fully ossified, and free of soft tissue, prepared through natural maceration and sun-drying for academic use. No chemical defleshing was applied. Bones were visually inspected and cleaned of dust or debris as needed. The inclusion criteria for this study were fully ossified, intact, dry adult clavicles; and exclusion criteria were the clavicles with incomplete ossification or fusion, bones showing deformities, fractures or decay. No skeletal remains from foreign students were included in this study to ensure population-specific relevance.

Each clavicle was weighed individually using a calibrated digital physical balance (Ningbo Ningshing Int. Inc., Model: TG928A, China, precision: ±0.01 gm) in a controlled environment. Prior to each weighing, the balance was calibrated using standard weights to ensure accuracy. Bones were placed centrally on the pan to ensure consistency.

Then the sex was determined by Discriminant Function Analysis (DFA) technique[15]. The technique was chosen due to its effectiveness in identifying sex based on measurements. It works well in morphometric studies by separating groups using numerical data. DFA gives clear formulas to classify bones as male or female and has been successfully used in many forensic and anthropological studies. This makes it more suitable than other methods like logistic regression. Demarking points were calculated by adding and subtracting three standard deviations to the mean value (mean ± 3SD). The range thus obtained was the 'calculated range', and the limiting points as determined on the basis of this range were 'demarking points'. Demarking points were derived for each variable to differentiate between the sexes. The data were analyzed using SPSS (version 22). Mean differences were calculated using unpaired t-test. Cohen's d standardized effect size was calculated along with t-test to see the clinical relevance. Receiver-Operating Characteristic (ROC) Curve analysis performed to evaluate sensitivity and specificity of the values gained from the demarking points. All the tests were done under 95% confidence interval, a p-value of <0.05 was considered as significant result. Prior to commencement of the study, ethical approval obtained from the institutional ethics committee (Memo No/SOMC/2019/33).

Photograph no1 Calculating the clavicle's weight using physical balance

Results

The weight of right male clavicular weight ranged from 10.5gm to 26.5 gm with a mean value of 17.46±4.84gm; while the female's right clavicular weight ranged from 6.6 gm to 20.1 gm with a mean value of 12.85±3.96 gm. The mean weight difference between the right male and female clavicle was found to be 4.61gm, which was statistically highly significant (d = 1.017, 95% CI: 1.171 – 8.049, p = 0.013).After calculation of demarking points, a right clavicle weighing >24.73 gm was found definitive for male gender and weighing <2.94 gm was found definitive for female gender. The left male clavicular weight found ranged from 8 gm to 30 gm and of female clavicular weight found ranged from 6.5gm to 19.0 gm. The mean weight of the male's left clavicle was found 18.91±6.09 gm and that of female's clavicle was 12.36±3.35 gm. The mean difference in weight between the male and female clavicle was found to be 5.61gm, which was found statistically highly significant (d = 1.275, 95% CI: 2.985 – 10.115, p<0.001). After calculating the demarking points, left clavicle with its weight >22.41gm found to be definitive for male gender and that with weight <0.64gm for female gender (Table 1 and Figure 1).

Table 1: Discriminant analysis of weight of male and female clavicle.

Details of measurements	Right		Left	
	Males (n = 18)	Females (n = 11)	Males (n = 18)	Females (n = 13
Range	10.5 – 26.5	6.6 – 20.1	8.0 – 30.0	6.5 – 19.0
Mean±SD	17.46±4.84	12.85±3.96	18.91± 6.09	12.36 ±3.35
Median	15.75		18.00	
Calculated range (Mean±3 SD)	2.94 to 31.98	0.97 to 24.73	0.64 to 37.18	2.31 to 22.41
Demarking point	>24.73	<2.94	>22.41	<0.64

SD=Standard deviation

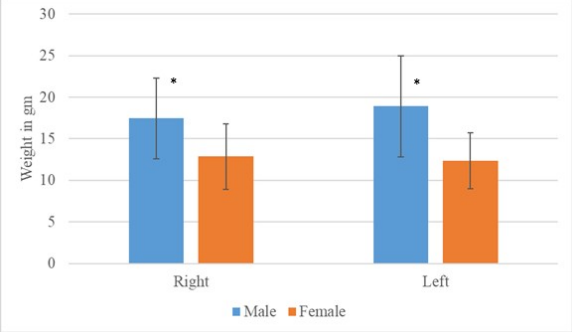

Figure 1: Comparison of right and left clavicular weight between the male and female gender.

The demarking points for both right and left clavicular weight were further analyzed in Receiver-Operating Characteristic (ROC) Curve analysis where the area under curve (AUC) found for the right clavicle was 0.642 (95% CI: 0.433 – 0.851) and for the left clavicle was 0.526 (95% CI: 0.313 – 0.739) for this study sample. The demarking point for the male's right clavicle (24.73 gm) showed 11.8% sensitivity and 8.3% specificity and for the left clavicle (22.41 gm) showed 38.9% sensitivity and 15.4% specificity in this study sample. In contrast, the demarking point for the female's right clavicle (2.94 gm) showed 100% sensitivity and 100% specificity and for the left clavicle (0.64 gm) showed 100% sensitivity and 100% specificity too in this study sample. However, further analysis showed that median value of right clavicle (17.5 gm)produce result at58.8% sensitivity and 33.3% specificity, and 18.00gm for the left clavicle as it showed 44.4% sensitivity and 61.5% specificity.

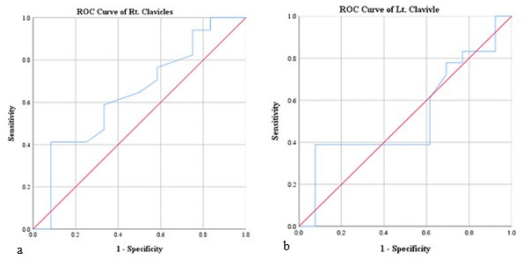

Figure 2: Receiver-Operating Characteristic (ROC) Curve analysis for the clavicular weight in (a) right and (b) left between male and female gender.

Discussion

Determination of gender from the available decomposed bone is an important medicolegal parameter. In previous studies, many other bones were widely used to determine gender. However, morphometric measurements are preferred due to their reproducibility and accuracy. Earlier measurements of showed that men have comparatively greater bone dimensions than the women. This is applicable for the clavicle bone as well. This study compared and analyzed for gender identification using clavicular weight between right and left clavicle. Mean comparison of weight of clavicles as estimated by different workers summarized in the Table 2. From the table, it was clear that, studies including the present one, there is a statistically significant difference in clavicle sex based on weight (p = 0.013 for the right and p = <0.001 for the left clavicle).

Table 2: Comparison of clavicular weight of male and female gender in different authors from different region.

Author and Region	Side	MALE		FEMALE		p value
		Mean	Range	Mean	Range	
Jit and Singh, 1966[11] Amritsar Zone	Rt	18.89	7.82-29.96	12.47	4.07-20.87	<0.001
	Lt	18.68	6.05-31.31	12.03	3.96-20.10	
Singh and Gangrade, 1968[16] Varanasi Zone	Rt	21.46	8.85-34.08	12.83	4.60-21.07	<0.001
	Lt	21.32	8.92-33.73	12.84	4.94-20.75	
Jit and Sahni, 1983[17] Chandigarh Zone	Rt.	25.78	19.0-42.0	17.55	11.10-23.00	<0.001
	Lt.	25.34	19.0-45.9	17.21	11.00-24.0	
Kaur et al., 1997[18] Amritsar Zone	Rt	25.33	15.0-38.0	16.56	8.30-23.80	<0.001
	Lt.	24.92	14.9-36.80	16.39	8.60-24.00	
Padeyappanavar et al., 2009[6] North Interior Karnataka	Rt	16.99	11.0-28.0	10.31	4.0-17.0	<0.001
	Lt	17.08	10.0-31.0	10.7	05.0-18.0	
Present study Bangladesh	Rt	17.46	10.5-26.5	12.85	6.6-20.1	0.013
	Lt	18.91	8.0-30.0	12.36	6.5-19.0	<0.001

In this present investigation, mean weight of rt clavicle in male (17.46gm) is comparable with the studies of Padeyappanavaret al. (16.99gm)[6] and Jit and Singh (18.89gm)[11], but lesser than as reported by Jit and Sahni (25.78gm)[17], Kaur et al. (25.33 gm)[18]and Singh and Gangrade(21.46gm)[16]from north Indian clavicles. The north Indian population are better nourished and well-built compared to the average Bangladeshi population. The measurement is same with right and left male and right and left female clavicles also. According to the observation by Jit and Singh on clavicles of Punjabi adults, right clavicle weighing >18 gm may be considered as male bones and that weighing <10gm as female. Thus 46% of male right clavicles may be labeled as male while only 17.6% of female right clavicle as female bones. Similarly, on the left side, clavicle weighing >18gm may be identified male clavicles, and those weighing <10gm as female, thus 44% left male and 22.9% left female clavicles can be considered as male and female Clavicles respectively. On applying demarking points, only 24% of male right and 35%of male left can be definitely sexed as male compared to only 2% of right and0% of left female clavicles. In the present investigation the weight of male right clavicle weighing >24.73gm is considered as male and that weighing <2.94gm as female clavicles, thus only15% of male right clavicles are identified as male, while 47% of right female clavicles as female bones. Similarly, on left side, clavicle weighing >22.41 gm is considered as male and that weighing <0.64 gm on female. Thus 29% left male clavicles are considered as male and 40% of left female clavicles as female bones. The accurate sex prediction will drop to just 7.69% in male right clavicles and 17.4% in male left clavicles, and 17.7% in right female clavicles and 0% in left female clavicles upon applying the demarking point. These findings are close to those of Jit and Singh study[11].

Earlier studies only used demarking point to establish gender identification. Demarking point has two values – above the upper value used to determine male gender and below the lower value used to determine female gender. The limitation of demarking points analysis is that the values between upper and lower range unable to define the gender clearly. We further used Receiver-Operating Characteristic (ROC) Curve analysis to identify one definitive point of demarcation for gender identification. However, we compared only upper value of demarking point that did not showed good result of sensitivity and specificity. Based on the result of the ROC analysis, there were wide difference found in sensitivity and specificity of male's demarking point of right and left clavicle and female's demarking point of right and left clavicle. However, we recommend further large-scale studies using ROC analysis to identify one definitive point of demarcation between the gender identification.

Conclusion

The results of the study on determining the sex of an adult human clavicle using morphometric criteria differed somewhat from those of previous research conducted by other researchers. This study shows the weight was better parameters which individually yield high probability of sex prediction. For sex distinction, these weight differences between the male and female clavicles are statistically significant.

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