GENDER DETERMINATION IN ADULT EGYPTIANS FROM COMPLETE AND FRAGMENTARY TIBIAE. AN ANTHROPOLOGICAL STUDY

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ABSTRACT

Sex determination from skeletal remains forms an important component in the identification procedure. The aim of the present study was to establish standards for determining sex from complete or fragmentary tibiae in the adult Egyptians. The study was carried out on 100 tibial bones with previously known sex (64 males and 36 females). Seven tibial dimensions were used; condylo-malleolar length; circumference at the nutrient foramen; minimal shaft circumference; anteroposterior dimension at nutrient foramen; transverse dimension at nutrient foramen; proximal epiphyseal breadth; and distal epiphyseal breadth. Four discriminant functions were generated; one using the seven variables, one using two variables, and two employing one variable. The results showed that complete tibiae can be sexed with 86.4% accuracy using the seven variables, and the same degree of accuracy was achieved using only two variables, while discriminant functions employing one variable showed accuracies of 66.7% and 77.3%. The study concluded that the tibia (fragmentary or complete) can be used for sex determination with a high degree of accuracy from 66.7% up to 86.4%.

Key words: Sex characteristics; Discriminant analysis; Tibia; Forensic anthropology; Egypt.

INTRODUCTION

"The record of organic evolution is largely written by the hard parts of the body, recognizable even after many years of death". This statement, by Krogman and Iscan (1986), reflects the role of the skeleton in estimating attributes such as age, sex, race, stature and disease.

The determination of sex is statistically the most important criterion, as it immediately excludes approximately half of the population whereas age, stature and race each provide points within a wide range of variables (Knight, 1991).

Sex determination from skeletal remains forms an important component in the identification procedure. Previous studies have demonstrated that populations differ from each other in size and proportion, and that these differences can affect the metric assessment of sex (Birkby, 1966; Iscan and Miller-Shaivitz, 1984; Macho, 1990).

However, sex identification sometimes becomes a difficult task for the forensic anthropologist, especially in the absence of the pelvis or the skull. These parts were relied upon in earlier studies because they exhibit the most obvious sexual dimorphism (DiBennardo and Taylor, 1983; Schulter-Ellis and Hayek, 1984).

A serious problem is that parts of the pelvis are relatively fragile and are often poorly preserved or completely missing from the skeletal remains. Also, sexing of the skull is largely dependent on the presence of complete crania (Kelley, 1979). Because of these limitations, other more resistant skeletal elements were used for sexing.

The tibia is the second largest bone in the skeleton. It is an ideal bone, for anthropological studies, because it resists erosive forces and keeps its anatomical shape for a long time, even after burial (Steyn and Iscan, 1997).

Hence, the aim of the present study was to establish standards for determining sex from the tibia, complete or fragmentary, among the adult Egyptians.

MATERIAL AND METHODS

The sample of the study consisted of 100 complete adult tibiae with known sex (64 males and 36 females). The sample was obtained from the Anatomy and Forensic Medicine Departments, Alexandria University. Abnormal or pathologically deformed bones were excluded from the study.

Seven osteometric dimensions were taken, to the nearest millimeter, from each tibia (Iscan and Miller-Shaivitz 1984b): (Figure 1).

1- Tibial length = Condylo-malleolar length (CML):

   This was measured from the medial malleolus to the lateral condyle.

2- Circumference at the nutrient foramen level (CNF).

3- Minimum shaft circumference (MSC).

4- Anteroposterior dimension at the nutrient foramen level (APNF).

5- Transverse dimension at the nutrient foramen level (TNF).

6- Maximal proximal epiphyseal breadth: which is the maximum distance between the condyles (MPEB).

7- Maximal distal epiphyseal breadth: which is the distance between the medial malleolus and the center of the fibular notch (MDEB).

An osteometric board and sliding caliber were used for measuring all dimensions except circumferences which were measured using a plastic covered tape.

In order to test for bilateral variation in the measurements, dimensions of 20 sets of tibiae were subjected to a paired t-test. The difference was found to be insignificant at the 0.05 level, thus allowing the bones of both sides (right and left) to be grouped together.

However, only one bone from each skeleton, either left or right, has been included in the analysis.

Data were analysed using the SPSSX subroutine software (SPPSS Incorporated). Stepwise discriminant function analysis, employing the recorded measurements, was used to determine the optimal combination of variables for assessing sex. Variables, alone and in combinations, were also subjected to direct analysis to develop functions to allow sexing from complete and fragmentary tibiae (Nie et al., 1975).

RESULTS

The descriptive statistics for both sexes are demonstrated in table (1). This table shows that the index of dimorphism, which is mean of male measurements, divided by mean of female measurements and multiplied by 100, is always greater than 100, indicating that males have greater tibial dimensions. The highest value of index is seen in the APNF, having a difference of 21.59%.

The mean male measurements were statistically greater than the mean of female measurements. The difference between males and females was highly statistically significant in all variables indicating a strong sexual dimorphism (Table 1).

Once the existence of a strong sexual dimorphism was determined, discriminant analysis for all variables was done using Wilk's Lambda test (Table 2). The F-ratio shows that the APNF made the greatest contribution in the analysis, followed by the CNF and the CML. While the TNF contributed the least in the analysis.

A stepwise discriminant function was then performed where four discriminant functions were used. The selection of variable combination (s) was based on the DIRECT method according to the entry sequence into the stepwise analysis. The first function (Table 3) employed all seven variables. The second function (Table 4) employed two variables (CML and APNF), while the third and fourth functions were generated to determine sex from fragmentary tibiae, and used only a single variable (MPEB for upper end tibia, and MDEB for the lower end) (Table 5).

Standardized coefficients indicate the

relative contribution of each variable to the function, while unstandardized coefficients are used for calculating discriminant function scores from the raw data. A dicriminant score is obtained by multiplying each variable with its unstandardized coefficient and adding them together along with the constant. If the score is greater than the sectioning point the individual is considered male, a lower score indicates a female.

In the first function (Table 3), where all seven variables were employed, the overall accuracy was 86.4% for both sexes. Classification accuracy was higher in males (91.3%) than in females (75%).

In the second function (Table 4), where two variables were combined (APNF and CML), surprisingly the same accuracy was obtained as that of function one, which used all seven variables (86.4%).

Discriminant functions using a single variable (Table 5), namely functions 3 and 4, provided lower accuracies with 66.7% for MPEB and 77.3% for MDEB.

Table (1): Sexual dimorphism and unifactorial statistics of the tibia in the analyzed sample.

Variable	Male (n=64)		Female (n=36)		Sexual dimorphism		
	$\overline{X}$	SD	$\overline{X}$	SD	Index [a]	t	P
CML	37.04	2.62	33.27	2.08	111.30	5.69*	0.000
CNF	9.39	0.72	8.19	0.83	114.70	5.95*	0.000
MSC	7.24	0.69	6.53	0.56	110.98	4.08*	0.000
APNF	3.49	0.38	2.87	0.35	121.59	6.12*	0.000
TNF	2.36	0.25	2.14	0.29	110.52	3.17*	0.002
MPEB	7.09	0.55	6.50	0.28	109.02	4.49*	0.000
MDEB	4.23	0.37	3.86	0.28	109.39	3.94*	0.000

*Significant at $P \leq 0.05$

[a] Index = Male $\overline{X}$ / Female $\overline{X}$ X 100

$\overline{X}$ = Mean.

Table (2): Discriminant function analysis of variables of the tibia using Wilk's Lambda and F-ratio.

Variable	Wilk's Lambda	F-ratio	p-value
CML	0.664	32.352*	0.000
CNF	0.644	35.434*	0.000
MSC	0.794	16.631*	0.000
APNF	0.625	38.415*	0.000
TNF	0.864	10.056*	0.002
MPEB	0.760	20.161*	0.000
MDEB	0.805	15.511*	0.000

*Sig. at $P \leq 0.05$

Table (3): Function 1 in stepwise analysis showing standardized and unstandardized coefficients and equation for sex determination from complete tibiae.

Variable	Standardized coefficients	Unstandardized coefficients	Accuracy
CML	0.578	0.234	
CNF	1.189	1.574	
MSC	-1.127	-1.716	
APNF	0.380	1.017	
TNF	-0.123	-0.466	
MPEB	0.084	0.173	
MDEB	0.090	-0.262	
Constant		-12.945	
Sectioning point		0.63	86.4%

Y= -12.945 + (CML X 0.234) + (CNF X 1.574) + (MSC X -1.716) + (APNF X 1.017) + (TNF X -0.466) + (MPEB X 0.173) + (MDEB X -0.262)

If Y ≥ 0.63 individual is male.

Y < 0.63 individual is female.

Table (4): Function 2 in stepwise analysis showing standardized and unstandardized coefficients and a second equation for sex determination from complete tibiae.

Variable	Standardized coefficients	Unstandardized coefficients	Accuracy
CML	0.471	0.191	
APNF	0.651	1.741	
Constant		-12.59	
Sectioning point		0.55	86.4%

Y= -12.59 + (CML X 0.191) + (APNF X 1.741)

If $Y \geq 0.55$ individual is male.

$Y < 0.55$ individual is female.

Table (5): Function 3 and 4 in stepwise analysis showing unstandardized coefficients and equation for sex determination from upper and lower ends of tibiae.

Variable	Unstandardized coefficients	Accuracy	Equation
MPEB	2.048		**Y=-14.157+ (MPEB X 2.048)**
Constant	-14.157		
Sectioning point	0.36	66.7%	$Y \geq 0.36$ male $Y < 0.36$ female
MDEB	2.901		**Y= -11.938+(MDEB X2.901)**
Constant	-11.938		
Sectioning point	0.32	77.3%	$Y \geq 0.32$ male $Y < 0.32$ female

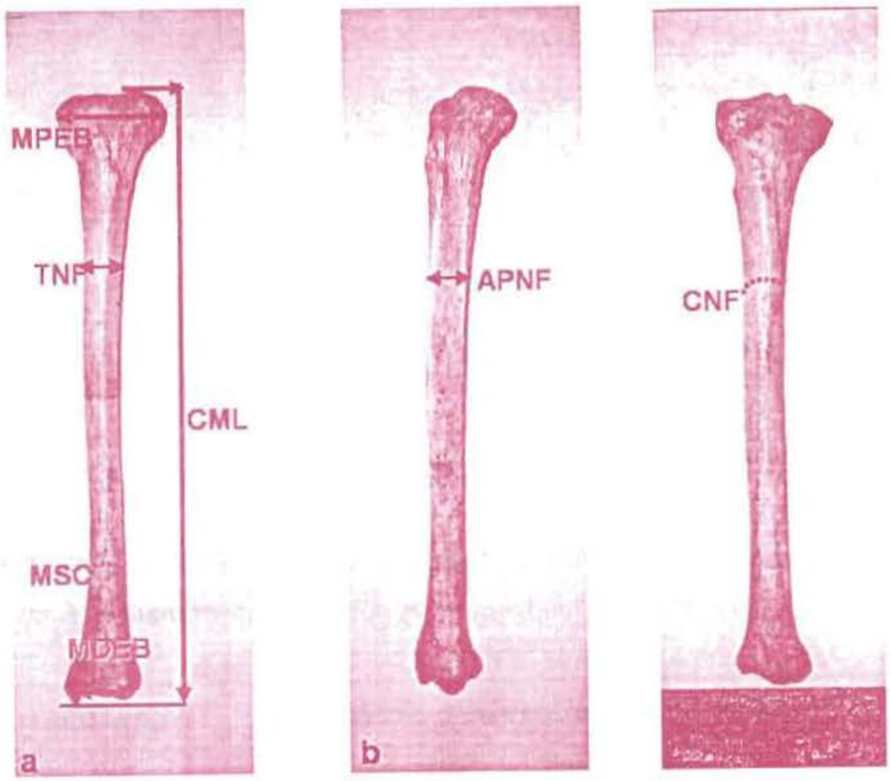

Figure (1): Photograph of left tibia (a: anterior surface view. b: lateral view. c: posterior surface view) shows the osteometric dimensions used in the study.

DISCUSSION

Skeletal biologists have long recognized that each population group requires its own specific standards for accurate determination of sex, and that it is necessary to calculate discriminant functions on samples from different geographic areas. Iscan et al. (1994) have shown that, overtime, changes can occur in a single population due to differences in nutrition, disease or population mobility, and that specific discriminant functions must be developed to take into account temporal changes within a particular population.

The tibia is a large and robust bone. It is known to preserve its anatomy, even after burial, and thereby a good choice for arthropological studies. In the present study, the mean values for the seven tibial dimensions measured were significantly higher in males than females. This indicates strong sexual dimorphism in the analyzed sample and the usefulness of these variables in evaluating morphological differences between sexes.

It is known that the average male skeleton is larger and heavier than the average female, although the magnitude of difference varies from one population to another. This sex difference can be the result of genetic factors, environmental factors affecting growth and development, or the interaction of both (Trancho et al., 1997).

It is also affected by the health status of the sample. Although it is not known which dimensions would be most affected by an inadequate diet, it is possible that differential growth factors affect the differences between the sexes (William et al., 1989). This theory agrees with the findings of Iscan and Miller-Shaivitz, (1984a) who reported a higher dimorphism in blacks than whites, indicating that determination of sex required a consideration of nutritional, physical and genetic (racial) factors.

In the present study the overall accuracy in sex determination, using all seven variables, was 86.4%, with classification accuracy higher in males than in females (91.3% and 75% respectively). This finding agrees with that of Iscan et al., (1994). They had a classification accuracy of 96% and 79% in males and females, respectively among Japanese population. The gap in the accuracy between sexes is probably due to the combined effect of unequal sample size and intrasex variations.

In discriminant analysis, the greatest contribution was for the anteroposterior dimension at the nutrient foramen level. It is believed that breadth dimensions provide better sex separation than length. Black (1978) attributed this to differential bone remodeling, between males and females, that leads to greater cortical bone development during adolescence that remains unchanged throughout adulthood.

This differential bone development primarily affects breadth and circumference measurements.

Another great contribution was for the condylo malleolar length (CML), while the maximal epiphyseal breadth had moderate contribution. Steyn and Iscan (1997) reported that the distal breadth provided the best discrimination in South African whites. They attributed this finding to the theory of DiBennardo and Taylor (1982), who suggested that epiphyseal measurements are more reliable indicators of sex because the functional demands of weight and musculature concentrate on these parts of the bone.

In the present study, sexing of complete tibiae using all seven variables gave an accuracy of 86.4% and when two variables were employed, namely CML and APNF, based on the variables selected by the stepwise discriminant function analysis, the same accuracy was obtained. This was not in agreement with the results of Slaus and Tomicic (2005) who achieved lower accuracies using two variables. This suggests that function 2 (employing two variables) could be considered in sexing of well-preserved, complete tibiae instead of function 1 (employing all seven variables).

It is a common experience for the forensic expert to be confronted with poorly preserved or fragmentary bones, thus, it is necessary to have sex determination techniques applicable to various parts of the bone. In the present study the proximal and distal epiphyseal breadths were chosen to be employed separately in two discriminant functions (3 and 4).

The results revealed accuracy in sex determination of 66.7% and 77.3% respectively, which could be used in sexing fragmentary tibiae.

In conclusion, the tibia is considered a good source for sex determination in the adult Egyptians, with excellent accuracy in case of complete, well-preserved bones (86.7%). Furthermore, the results proved sexing from fragmentary tibiae, with degrees of accuracies (up to 77.3%), which would be enhanced if used in association with other available data.

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تحديد النوع فى المصريين البالغين من عظمة القصبة أو أجزائها
دراسة أنثروبولوجية

المشتركون فى البحث

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يشكل تحديد النوع من البقايا العظمية جزءاً هاماً من عملية الاستعراف. ولهذا كان الهدف من الدراسة هو وضع معايير لتحديد النوع من عظمة القصبة الكاملة أو أجزائها فى المصرين البالغين.

و أجريت الدراسة على عدد مائة عظمة قصبة كاملة معروفة النوع (64 ذكر و36 أنثى) وتم قياس سبعة أبعاد على العظمة شملت الطول اللقمى الكعبى، محاط العظمة عند الثقب المغذى، أصغر محاط لجسم العظمة، البعد الأمامى الخلفى للعظمة عند الثقب المغذى، البعد العرضى عند الثقب المغذى وعرض المشاشة الدانية بالجزء العلوى والقصوى بالجزء السفلى من العظمة.

تم تطبيق أربع وظائف تميزية تحليلية فى الدراسة الإحصائية لهذا البحث حيث استخدم فى الوظيفة الأولى سبع أبعاد لعظمة القصبة وفى الوظيفة الثانية البعدين الأكثر دلالة إحصائية. أما فى الثالثة والرابعة فقد استخدم بعد واحد فقط ليمثل كل من الجزء العلوى والسفلى للعظمة.

وقد أظهرت الدراسة أن عظمة القصبة الكاملة يمكن تحديد نوعها بدقة تصل إلى 86.4% باستخدام السبعة أبعاد وبنفس النسبة من الدقة باستخدام بعدين فقط (الطول اللقمى الكعبى و البعد الأمامى الخلفى للعظمة عند الثقب المغذى) بينما أظهر التمييز الوظيفى الإحصائى لاستخدام بعد واحد فقط لكل من الجزء العلوى والسفلى للعظمة دقة بنسبة 66.7% و 77.3% على الترتيب وعليه استخلصت الدراسة أن عظمة القصبة الكاملة أو أجزائها (فى حالة تفتتها) يمكن استخدامها لتحديد نوع الجنس بنسبة عالية من الدقة تصل إلى 86.4%.