ANTHROPOLOGIE • XLIII/1 • pp. 45–49 • 2005

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ANTHROPOMETRIC MEASUREMENTS OF FEMUR AND TIBIA ON THE BYZANTINE SKELETONS OF NICEA REMAINS (13th CENTURY A.D.)

ABSTRACT: Skeletal anthropometric measurements to reveal regional diversity between different populations or within the same one are beneficial for understanding temporary evolutionary and developmental progress relevant to our species.

Our material consisted of 26 femurs (13 left, 13 right) and 60 tibias (30 left, 30 right) of male Byzantine skeletons (13th century) excavated at Nicea in Turkey, between 1981 and 1985. Twelve osteometric parameters for femurs and five for tibias were taken into account. Indices of platymeria and platycnemia were derived and compared with other studies. Non-paired t-tests were used to compare left and right. No noticeable difference was found for femurs. Antero-posterior diameter at the nutrient foramen of tibias showed minimal difference between the left and right. The platymeric index was eumeric (mean = 86). Our material indicates the existence of eurycnemia with respect to tibial flattening (mean = 74).

KEY WORDS: Morphometry – Femur – Tibia – Platymeria – Platycnemia

INTRODUCTION

The human skeleton shows differences in different societies. Human skeletal features and variations are related to genetic and environmental factors (climate, geography, diet, lifestyle etc.) (Bacon 1990, Erickson *et al.* 2002, Kohn 1991, Larsen 1995, Roberts, Bear 1972). Also the features and variations of the human skeleton determine the racial characteristics of the populations which are connected with evolutionary differentiation of the human species.

Skeletal anthropometric measurements to reveal regional diversity between different populations or within the same one are beneficial for understanding temporary evolutionary and developmental progress relevant to our species.

Postcranial measurements are contemporary in race specific studies while cranial measurements were principal standard approach for many years. Skeletal measurements of long bones have an importance for studies of races. There are large numbers of various parameters for the long bones, especially the femur; measurements of the tibia offer an additive standpoint for forensic and anthropological studies as the other postcranial bones (Gill 2001, Iscan 1990, Iscan, Cotton 1990).

In this study, we have evaluated specific parameters and compared the data with other studies, for the male femora and tibia which were preserved after discovering an archaeological site dated to the Byzantine period. Then, we tried to reveal some osteometric features for that population.

MATERIALS AND METHODS

Our materials were twenty six femora (13 left, 13 right) and sixty tibias (30 left, 30 right) of the late Byzantine period (13th century) excavated from Nicea, Turkey, between 1981 and 1985; all of them were adult males (mean 35 years) (Ozbek 1984). The bones did not belong to the

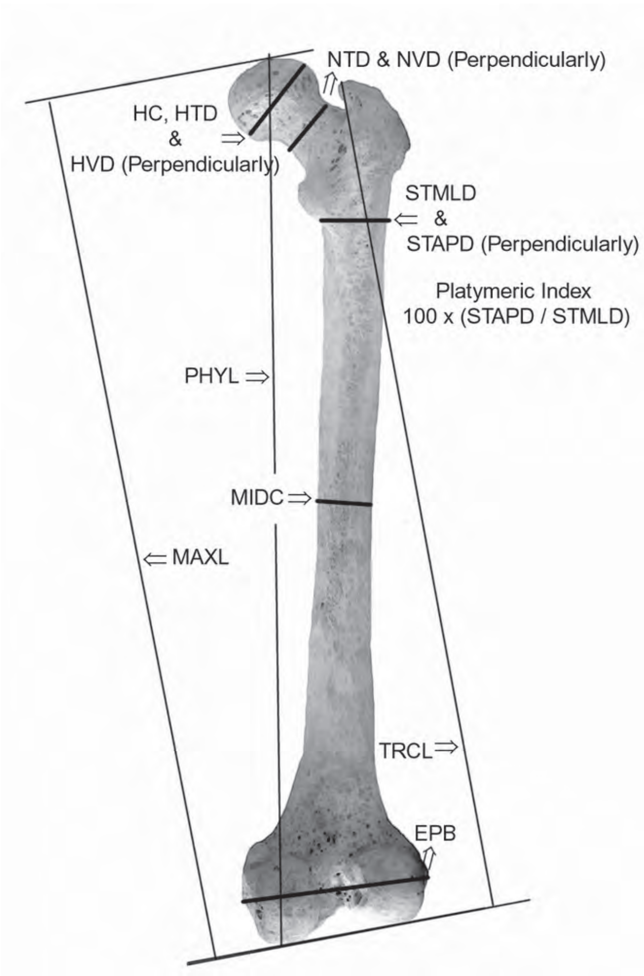

FIGURE 1. Osteometric parameters and indices of Byzantine femora. **STMLD:** Sub-trochanteric medio-lateral diameter; **STAPD:** Sub-trochanteric antero-posterior diameter; **EPB:** Epicondylar breadth; **HTD:** Head transverse diameter; **HVD:** Head vertical diameter; **HC:** Head circumference; **NVD:** Neck vertical diameter; **NTD:** Neck transverse diameter; **MAXL:** Maximum length; **PHYL:** Physiological length; **TRCL:** Trochanteric length; **MIDC:** Mid-shaft circumference.

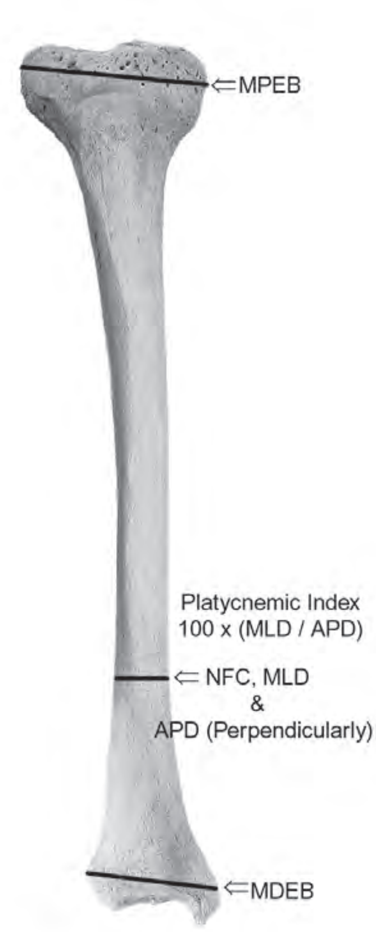

FIGURE 2. Osteometric parameters and indices of Byzantine tibias. **APD:** Antero-posterior diameter at the nutrient foramen; **MLD:** Medio-lateral diameter at the nutrient foramen; **MPEB:** Maximum proximal epiphyseal breadth; **MDEB:** Maximum distal epiphyseal breadth; **NFC:** Circumference at the nutrient foramen.

same individuals. Complete and uncorrupted bones were included in the study and the measurements were taken by the same person. Measurements were taken by using an osteometric board, a metric tape and a sliding caliper. Twelve osteometric parameters were considered in our measurements for femora, where an index of platymeria is also derived for that material, and five osteometric parameters were considered for tibial features, where an index of platycnemia was also derived. We also compared our data with other studies directly, and used nonpaired t-test to compare left and right groups. SPSS statistical program was used for statistics.

Femoral parameters considered to reveal the wide dimension of these complex racial features were: maximum length (MAXL), physiological length (PHYL), trochanteric length (TRCL), sub-trochanteric medio-lateral diameter (STMLD), sub-trochanteric antero-posterior diameter (STAP), epicondylar breadth (EPB), head transverse diameter (HTD), head vertical diameter (HVD), head circumference (HC), neck transverse diameter (NTD), neck vertical diameter (NVD) and mid-shaft circumference (MIDC) (*Figure 1*). Besides we measured five tibial parameters which were: antero-posterior diameter at the nutrient foramen (APD), medio-lateral diameter at the nutrient foramen (MLD), maximum proximal epiphyseal breadth (MPEB), maximum distal epiphyseal breadth (MDEB), circumference at the nutrient foramen (NFC) (*Figure 2*; Brothwell 1981, Dibennardo, Taylor 1983, Martin, Saller 1957, Olivier 1969, Van Gerven 1972).

The platymeric index was calculated with "100 × (sub-trochanteric antero-posterior diameter / sub-trochanteric medio-lateral diameter)" formula. The tibial shaft index, platycnemia, is calculated at the level of the nutrient foramen and "100 × (mediolateral diameter / antero-posterior diameter)" formula was used (Brothwell 1981, Olivier 1969).

TABLE 1. T-test results for comparison of the left and right groups for femora. A total of twelve parameters were considered for analysis for equality.
STML: Sub-trochanteric medio-lateral diameter; **STAP:** Sub-trochanteric antero-posterior diameter; **EPB:** Epicondylar breadth; **HTD:** Head transverse diameter; **HVD:** Head vertical diameter; **HC:** Head circumference; **NVD:** Neck vertical diameter; **NTD:** Neck transverse diameter; **MAXL:** Maximum length; **PHYL:** Physiological length; **TRCL:** Trochanteric length; **MIDC:** Mid-shaft circumference (dimensions in millimeters).

	Right mean	Left mean	P
STML	26.204	26.023	0.859
STAP	29.369	31.05	0.156
EPD	80.638	79.404	0.655
HTD	54.92	53.47	0.773
HVD	91.03	92.90	0.874
HC	33.62	35.26	0.673
NVD	32.542	31.258	0.382
NTD	26.342	26.712	0.752
MAXL	450.92	435.92	0.296
PHYL	446.92	432.92	0.327
TRCL	424.15	412.62	0.404

RESULTS

Overall mean results for right and left femurs were (*Table 1*): The maximum length 443.42±35.97 mm, physiological length 439.92±35.73 mm, trochanteric length 418.38±34.36 mm, sub-trochanteric antero-posterior diameter 26.11±2.52 mm, sub-trochanteric medio-lateral diameter 30.21±2.99 mm, epicondylar breadth 80.02±6.84 mm, head transverse diameter 45.24±4.10 mm, head vertical diameter 45.85±3.67 mm, head circumference 144.06±12.45 mm, neck transverse diameter 26.53±2.90 mm, neck vertical diameter 31.90±3.67 mm, and mid-shaft circumference 88.81±8.59 mm. With these results the platymeric index was concluded as mean 86 (100 × sub-trochanteric antero-posterior diameter / sub-trochanteric medio-lateral diameter).

The mean results and standard deviations from the descriptive analysis for tibias were (*Table 2*): The maximum proximal epiphyseal breadth 74.23±5.11 mm, maximum distal epiphyseal breadth 54.20±3.63 mm, circumference at the nutrient foramen 91.97±7.30 mm, antero-posterior diameter at the nutrient foramen 34.44±3.59 mm, medio-lateral diameter at the nutrient foramen 25.65±2.57 mm. With these results, tibial shaft flattening index, platycnemia, was concluded as 74 (100 × medio-lateral diameter / antero-posterior diameter).

Nonpaired t-test was used to compare left and right groups; and we did not find any noticeable difference between the left and right femora. The smallest p value was 0.156 (sub-trochanteric antero-posterior diameter) and largest (head vertical diameter) 0.874. In addition all parameters for tibias showed smaller values than t critical except the antero-posterior diameter of the nutrient foramen which showed minimal difference between the left and right groups.

TABLE 2. T-test results of the left and right groups for tibias. A total of five parameters were considered for analysis for equality.
APD: Antero-posterior diameter at the nutrient foramen; **MLD:** Medio-lateral diameter at the nutrient foramen; **MPEB:** Maximum proximal epiphyseal breadth; **MDEB:** Maximum distal epiphyseal breadth; **NFC:** Circumference at the nutrient foramen (dimensions in millimeters) ($p>0.5$); (**APD*:** Results for the left and right groups for antero-posterior diameter at the nutrient foramen ($p<0.1$)

	Right mean	Left mean	P
APD*	33.62	35.26	0.078*
MLD	25.67	25.63	0.951
MPEB	73.29	75.17	0.155
MDEB	54.92	53.47	0.121
NFC	91.03	92.90	0.326

DISCUSSION

Platymeric index is described as the flattening of the upper part of the femoral shaft (100 × sub-trochanteric antero-posterior diameter / sub-trochanteric medio-lateral diameter). Classification of this index is as follows (Brothwell 1981): hyperplatymeria = below 75; platymeria = 75–84.9; eumeria = 85–99.9; stenomeria = from 100 upwards.

Platycnemia can be described as flattening of the tibia at the level of the nutrient foramen (100 × medio-lateral diameter / antero-posterior diameter). Classification of this index is as follows (Brothwell 1981): hyperplatycnemia = below 54.9; platycnemia = 55.0–62.9; mesocnemia = 63.0–69.9; eurycnemia = from 70.0 upwards.

It is believed that the flattening of the upper shaft, index of platymeria, is related with sex (index is definitely higher in women), diet and mechanical adaptations. Our material shows moderate values for this index (mean = 86), and was eumeric. Moreover, the flattening of the shaft of tibia, index of platymeria, is related with pathological, muscular factors and squatting attitude. Our material supports eurycnemia for this index (mean = 74). We could not compare these findings with similar studies.

Comparisons with other studies for femoral measurements are described below (*Table 3*): Wu (1989) measured lower values than our measurements of STAP (26.1 mm±2.2), EPB (77.8 mm±5.8), HTD (44.7 mm±3.2), HVD (42.7 mm±3.1), MAXL (431 mm±25.8), PHYL (426.8 mm±25.9) and TRCL (403.8 mm±25.7), but STML was greater (31.9 mm±3.1) for modern Chinese male femora.

Macho's (1990) values for sub-trochanteric measurements for Zulu, Sotho and Xosa male populations were lower than or close to our values; only Caucasoid male population show slightly greater values: STAP (30.1 mm±2.1), STML (32.6 mm±2.6). Similar differentiation for these groups can be seen for EPB, HTD, HVD, NVD and NTD. But all physiological length values (PHYL) of these four groups show greater values (from 452.2 mm for Zulus to 470.9 mm for Caucasoids).

TABLE 3. Comparison of the femoral anthropometric measurements with other studies.

Studies	Descrip.	STML	STAP	EPB	HTD	HVD	NVD	NTD	MAXL	PHYL	TRCL	MIDC
Present study Byzantine 13th cent.	♂ n=26 left&right	30.2 ±3.0	26.1 ±2.5	80.2 ±6.8	45.2 ±4.1	45.8 ±3.7	31.9 ±3.7	26.5 ±2.9	443.4 ± 36.0	439.9 ± 35.7	418.4 ± 34.4	88.8 ± 8.6
Ziylan 2002 (Seyh Hoyuk)	n=7 left&right	–	–	70.2 ±6.6	40.0 ±4.0	41.2 ±4.5	30.2 ±3.4	25.3 ±2.2	410.8 ±27.2	–	–	80.9 ±8.6
Ziylan 2002 (Anatolian)	n=72 left&right	–	–	77.1 ±5.5	44.5 ±3.7	44.3 ±3.7	30.6 ±3.3	25.9 ±2.9	422.5 ±51.9	–	–	87.7 ±7.0
Hershkowitz 1993 (K. El Ahmar)	♂ n=30 left&right	29.1 ±1.7	32.3 ±2.8	78.3 ±3.6 n=37	–	–	–	–	–	–	–	–
Macho 1990 (Zulu)	♂ n=40 left	30.3 ±2.1	27.2 ±2.2	79.9 ±4.0	46.0 ±2.7	46.7 ±3.4	32.3 ±2.5	27.3 ±2.6	–	452.2 ±23.1	–	–
Macho 1990 (Sotho)	♂ n=40 left	29.6 ±2.8	26.0 ±2.0	77.4 ±4.2	44.8 ±2.6	45.2 ±2.7	31.4 ±2.3	26.6 ±2.4	–	449.2 ±24.4	–	–
Macho 1990 (Xosa)	♂ n=41 left	31.3 ±2.4	27.4 ±2.4	79.4 ±3.8	45.8 ±2.2	46.3 ±2.1	32.0 ±2.1	27.3 ±2.4	–	456.0 ±18.5	–	–
Macho 1990 (Caucasoid)	♂ n=41 left	32.6 ±2.6	30.1 ±2.1	83.3 ±4.2	47.9 ±2.3	48.5 ±2.4	34.9 ±2.5	30.0 ±2.0	–	470.9 ±26.7	–	–
Wu 1989 (Chinese)	♂ n=74 left&right	31.9 ±3.1	26.1 ±2.2	77.8 ±5.8	44.7 ±3.2	42.7 ±3.1	–	–	431 ±25.8	426.8 ±25.9	403.8 ±25.7	84.6 ±6.9

TABLE 4. Comparative results of the tibial anthropometric measurements between the present and the other studies.

Studies	Descrip.	APD	MLD	MPEB	MDEB	NFC
Present study Byzantine	♂ n=60 left&right	34.4 ±3.6	25.6 ±2.6	74.2 ±5.1	54.2 ±3.6	92.0 ±7.3
Iscan 1984 (Terry Coll.) Whites	♂ n=40 left	34.6 ±3.3	26.63 ±3.9	75.5 ±3.6	47.8 ±3.2	96.1 ±5.8
Iscan 1990 (Hamann-Todd Coll.) Whites	♂ n=49 left&right	35.6 ±3.15	26.3 ±2.5	76.8 ±3.7	46.7 ±2.6	98.5 ±4.9
Iscan 1990 (Hamann-Todd Coll.) Blacks	♂ n=48 left&right	36.3 ±3.7	28.4 ±3.39	77.9 ±3.3	46.6 ±2.7	101.8 ±8.1

Ziylan (2002) obtained smaller values for a Chalcolithic Age material: EPB (70.02 mm±6.6), HTD (40 mm±4.0), HVD (41.2 mm±4.5), NVD (30.2 mm±3.4), NTD (25.3 mm±2.2), MAXL (410.8 mm±27.2) and MIDC (80.9 mm±8.6). They also obtained smaller values for their contemporary Anatolian material.

Hershkowitz *et al.* (1993) found smaller values for EPB (78.3 mm±3.6) than our values (male human remains from Khan el-Ahmar).

Our findings connected with tibial measurements were compared with the other studies in *Table 4*. Iscan (Iscan, Miller-Shaivitz 1984, Iscan 1990) found greater values than our measurements of APD (35.6±3.15, whites; 36.3±3.7, blacks), MLD (26.3±2.55, whites; 28.4±3.39, blacks), MPEB (76.8±3.68, whites; 77.9±3.32, blacks) and NFC (98.5±4.90, whites; 101.8±8.07, blacks), but MDEB parameter was lower (46.7±2.58, whites; 46.6±2.74, blacks) for the Hamann-Todd Collection. Besides, there were greater values than our measurements of APD (34.6±3.30, whites; 35.45±2.71, blacks), MLD (26.63±3.97, whites; 27.98±3.08, blacks), MPEB (75.50±3.62, whites; 77.23±4.14, blacks) and NFC (96.13±5.84, whites; 100.43±6.63, blacks), but MDEB parameter was lower (47.80±3.23, whites; 47.93±3.54, blacks) for the Terry Collection.

It seems obvious that anthropometric measurements could show differences between various populations from different age periods and diverse populations, and these may be considered to be constantly updated. However, it should be kept in mind that both the present study and the many previous studies have a small number of femora and tibias and while the results showed differences, it is worthwhile to perform similar studies with a large number of bones from different age periods and from diverse populations.

Nonmetric postcranial traits by themselves may not provide enough information to characterize a population, while the metric measurements help provide more specific and complete information on the ethno-historical background and evolutionary process of the population. The present study has proved that anthropometric measurements of the postcranial bones are helpful for characterization of this population at their time period, which was the purpose of its implementation.

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