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ORIGINAL ARTICLE

Evaluation of the effect of secular changes in the reliability of osteometric methods for the sex estimation of Portuguese individuals

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ABSTRACT

Physical secular changes in the human skeleton may interfere with the reliability of metric methods so these should be monitored from time to time to make sure that they are still up to date. In this research, sex estimation methods conventionally applied to the Portuguese population and developed on a collection from the 19th and early 20th centuries were tested in a sample of recently deceased individuals (N = 82) with the same ancestry composed of skeletons exhumed from the civil cemetery of Prado do Repouso (Porto). Referenced sex discriminating cut-off points were applied to the latter and the percentage of correct classification resulting from this procedure was calculated.

A positive secular trend was found for the dimensions of most features that were investigated with clear implications for metric sex estimation. In comparison with the published values, the correct classification rates obtained on the modern sample were smaller in most cases. In particular, the results indicated that the use of established references for tarsal bones to sex estimate recent individuals is unadvisable. Therefore, new metric references developed on modern individuals are needed for the evaluation of remains from recent forensic contexts. Alternatively, when those are not available, more conservative interpretations of the results obtained through the application of outdated references are required when applied to modern individuals.

Keywords: Biological Anthropology; Forensic Anthropology; biological profile; anthropometry; Portugal.

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RESUMO

A fiabilidade de métodos osteométricos correntemente utilizados por antropólogos biológicos é posta em causa por alterações físicas de natureza secular. Por essa razão, esses métodos métricos devem ser periodicamente testados de forma a confirmar se a sua fiabilidade se mantém. Para esse efeito, métodos convencionalmente aplicados à população portuguesa e desenvolvidos a partir de uma colecção de indivíduos que viveram durante o século XIX e o primeiro quartel do século XX foram testados em esqueletos de indivíduos com a mesma ancestralidade, recentemente falecidos (N =82) e exumados do cemitério do Prado do Repouso (Porto). Os pontos de corte de referência, sexualmente discriminantes, foram aplicados nestes últimos e a percentagem de classificação correcta daí resultante foi calculada.

Uma tendência secular positiva foi detectada na maioria das estruturas esqueléticas investigadas, demonstrando claramente a sua consequência na estimativa osteométrica do sexo. Comparados com os valores publicados, as percentagens de classificação correcta obtidas na amostra moderna foram inferiores na maioria dos casos. Em particular, os resultados indicaram que a utilização das referências referentes aos ossos do tarso é desaconselhável. Assim sendo, novas referências desenvolvidas em indivíduos modernos são necessárias para a avaliação de restos esqueléticos provenientes de contextos forenses recentes. Em alternativa, se estas referências não estiverem disponíveis, a adopção de interpretações mais conservadoras na análise de resultados fruto da aplicação de referências desactualizadas pode ajudar a diminuir o número de estimativas erradas.

Palavras-chave: Antropologia Biológica; Antropologia Forense; perfil biológico; antropometria; Portugal.

Introduction

Osteometry is widely used in Biological Anthropology for the sex estimation of unknown skeletal human remains. Although not as sexually dimorphic as the pelvis, long bones and tarsal bones are a good support for sex estimation and have the advantage of often being better preserved in both archaeological and forensic contexts (Silva, 1995; Wasterlain and Cunha, 2000; Spradley and Jantz, 2011). However, metric methods have clear disadvantages as well. They tend to be population specific and therefore their reliability is quite vulnerable when applied across populations. Differences in size, shape and sexual dimorphism are at the root of this problem (Işcan et al., 1998; Albanese et al., 2005; Cardoso, 2008). In addition, metric methods are quite affected by secular changes in stature (e.g. Jantz, 1992; Buretić-Tomljanović et al., 2006) and the latter has been recurrently documented in several populations being caused by several factors such as nutrition or socio-economical status (e.g. Trotter and Gleser, 1951; Sandberg and Steckel, 1980 and 1987; Meadows and Jantz, 1995; Padez and Johnston, 1999; Silventoinen et al., 2001; Padez, 2003 and 2007; Garcia and Quintana-Domeque, 2007; Conceição et al., 2012). Therefore, it makes sense that the trustworthiness of metric methods be routinely evaluated. Mistaken estimations can have critical implications, especially in forensic cases involving recent individuals. The objective of this paper is to test the reliability of metric methods that were developed on skeletal samples from the Portuguese population.

The methods here tested were developed based on the Identified Skeletal Collection of the University of Coimbra (Silva, 1995; Cunha and Wasterlain, 2007) that comprises individuals born between 1826 and 1922 and deceased between 1910 and 1936. Therefore, several decades separate us from the most recent individual of that collection. Cardoso (2000) also developed metric methods for the humeral and femoral features here addressed, based on a sample of Portuguese identified skeletons from the collection housed at the Bocage Museum of the University of Lisbon (Cardoso, 2006). Although the time span of the individuals comprising this collection is somewhat larger and extending to more recent times – birth dates between 1807 and 1955 and death dates between 1880 and 1969 – his references are statistically the same as the ones from Wasterlain and Cunha (2000) and were therefore not tested in this investigation to avoid redundancy.

Expectantly, this research contributes for the discussion about the effect of skeletal secular changes on the metric methods that are conventionally used by biological anthropologists.

Material and Methods

Testing of the references from Silva (1995) and Wasterlain and Cunha (2000) – from now on designated as Coimbra references – was carried out in modern individuals that were assembled at the Cemetery of Prado do Repouso (Porto). The sample was composed of 82 skeletons recently exhumed and unclaimed by their relatives. Whenever this happens, the cemetery cremates the remains in order to free the burial slot so that it can receive a new inhumation. Before cremation, permission was granted for the measurement of some skeletal features of these individuals who died between 1990 and 2005.

The sample – from now on designated as modern sample – was composed of 41 females and 41 males with ages ranging between 27 and 99 years old (n = 45; mean = 73.3; sd = 16.8). In more detail, females presented ages between 30 and 99 years old (n = 29; mean = 75.8; sd = 14.7) and males were aged between 27 and 95 years old (n = 16; mean = 68.9; sd = 19.9). Regrettably, the age-at-death of 48 skeletons was unknown. In 11 cases, this personal detail was nonetheless obtained on the Civil Records Office.

The following standard measurements were taken with a digital caliper in each skeleton whenever preservation allowed it: humeral head transverse diameter (HHTD), humeral head vertical diameter (HHVD); humeral epicondylar breadth (HEB); femoral head transverse diameter (FHTD); femoral head vertical diameter (FHVD); talar maximum length (TML); and calcaneal maximum length (CML). Measurements are illustrated in Figure 1 and were carried out according to the instructions from Martin and Saller (1957). Other standard measurements on these bones were either not taken or resulted in small samples and were therefore not included in this investigation.

Each measurement was taken three times and the median value was used for the calculations. Parametric tests were used for inferential statistics since all assumptions were met. Sexual dimorphism in the modern sample was assessed by using a t-test for independent samples. In addition, mean differences between the modern sample and the Coimbra samples were tested through a One-sample t-test to infer about possible secular changes in the dimensions of the features here investigated. The Statistical Package for the Social Sciences (SPSS, version 14.0) was used for statistical testing. Finally, the sex estimation of the individuals from the modern sample was carried out by using the Coimbra references in order to see how these would perform when applied across populations. The published cut-off points were used (Table 1). In the case of Silva (1995), the discriminant functions were not tested because only the maximum lengths of the talus and calcaneus were taken into consideration for this study. Sexual dimorphism (sexdim) was calculated in terms of percentage using the following equation:

Sexdim = 100 – male mean measurement / female mean measurement * 100

Results

Table 2 gives the statistics of the humeral, femoral, talar and calcaneal features of the modern sample. All features presented significant sexual differences and the magnitude of those differences – measured in terms of effect size – was very large. In terms of sexual dimorphism – here expressed in percentage – the values from the modern sample were larger than the ones from the Coimbra references, with the exception of the talar maximum length.

Mean differences between the modern sample and the Coimbra references were not always significant. Table 3 gives the results of the One-sample t-tests that compared both assemblages. All modern measurements were larger than the ones from the Coimbra references. However, only the humeral head diameters and the calcaneal maximum length presented a significant size increase in the modern sample at the .01 level while the femoral head diameters presented a significant size increase only at the .05 level. The remaining features – the humeral epicondylar breadth and the talar maximum length showed no significant mean differences.

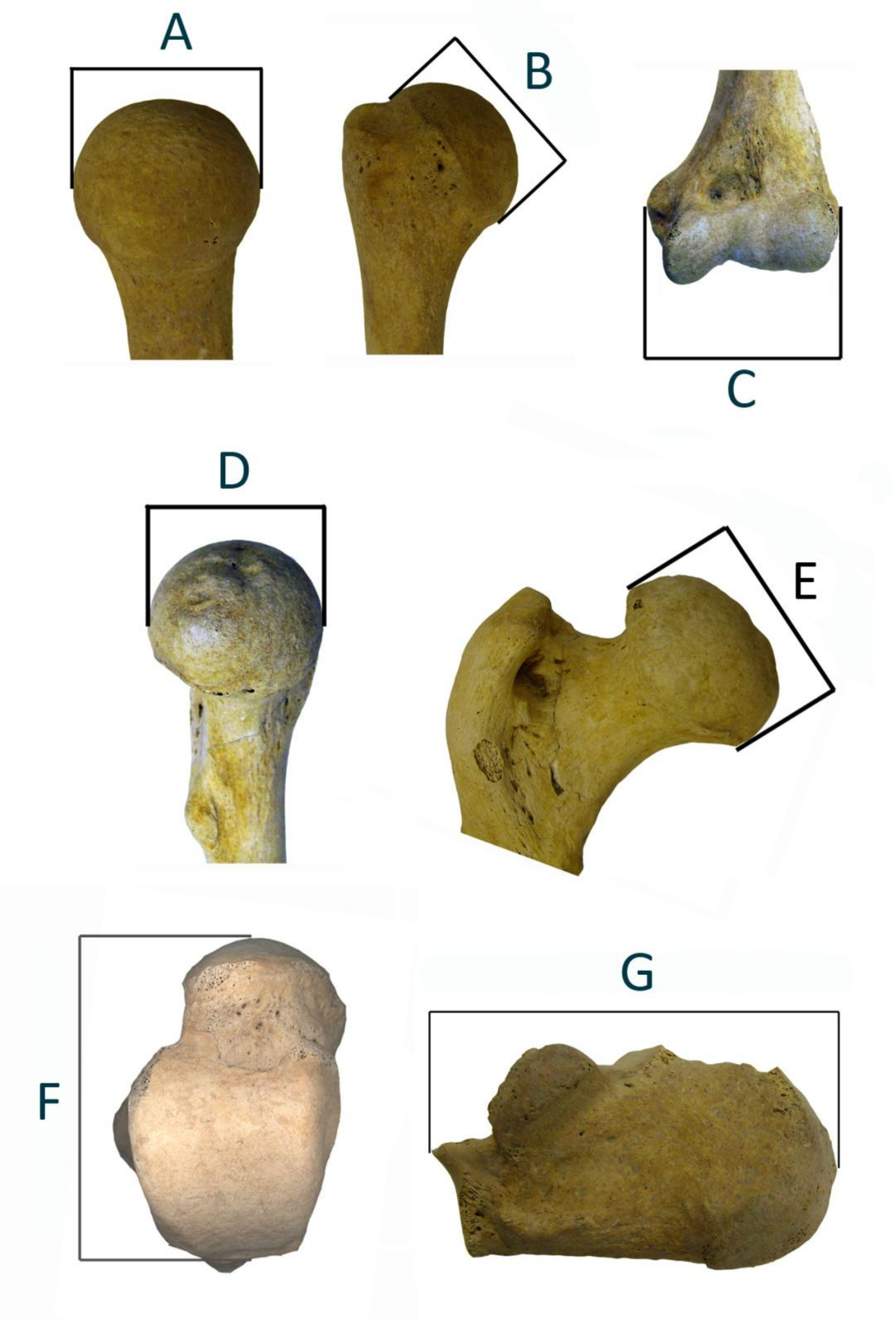

Figure 1. Illustration of the standard measurements taken in this investigation. A) humeral head transverse diameter (HHTD); B) humeral head vertical diameter (HHVD); C) humeral epicondylar breadth (HEB); D) femoral head transverse diameter (FHTD); E) femoral head vertical diameter (FHVD); F) talar maximum length; G) calcaneal maximum length.

Table 1. Sex discriminating cut-off points of the Coimbra references reported in mm.

Coimbra References	HHTD[a)]	HHVD[a)]	HEB[a)]	FHTD[a)]	FHVD[a)]	TML[b)]	CML[b)]
Cut-off point	39.38	42.36	56.63	42.84	43.23	52.00	75.50

Key: a) Wasterlain and Cunha (2000); b) Silva (1995)

Table 2. Descriptive and inferential statistics of selected standard measurements (StM) in the modern sample according to sex (in mm).

StM	Sex	N	Mean	S.D.	Max.	Min.	*t*	*df*	Sig.	*d*
HHTD	Female	28	37.8	1.6	40.4	35.2	-9.715	61	< .001	2.39
	Male	35	43.4	2.9	50.6	36.5				
	Pooled	63	40.9	3.7	50.6	35.2				
HHVD	Female	31	40.9	2.1	45.6	37.6	-9.387	67	< .001	2.37
	Male	38	47.3	3.2	52.9	40.3				
	Pooled	69	44.4	4.2	52.9	37.6				
HEB	Female	32	52.5	3.6	58.3	45.5	-10.043	68	< .001	2.43
	Male	38	61.6	3.9	69.0	52.4				
	Pooled	70	57.4	5.9	69.0	45.5				
FHTD	Female	35	40.8	2.4	45.9	35.2	-8.750	74	< .001	2.03
	Male	41	46.3	3.0	52.5	40.0				
	Pooled	76	43.8	3.9	52.5	35.2				
FHVD	Female	35	41.3	2.2	45.8	36.2	-9.805	74	< .001	2.23
	Male	41	46.8	2.7	51.9	41.1				
	Pooled	76	44.3	3.7	51.9	36.2				
TML	Female	41	49.7	2.8	56.0	44.0	-7.348	76	< .001	1.66
	Male	37	54.7	3.2	61.0	48.2				
	Pooled	78	52.1	3.9	61.0	44.0				
CML	Female	39	74.4	3.9	84.4	67.3	-7.123	73	< .001	1.64
	Male	36	82.2	5.5	92.2	67.6				
	Pooled	75	78.2	6.1	92.2	67.3				

Key: humeral head transverse diameter (HHTD), humeral head vertical diameter (HHVD); humeral epicondylar breadth (HEB); femoral head transverse diameter (FHTD); femoral head vertical diameter (FHVD); talar maximum length (TML); and calcaneal maximum length (CML).

Table 3. Mean differences in selected standard measurements (StM) between the modern sample and the Coimbra references (in mm) and respective sexual dimorphism.

StM	Sex	Mean	S.D.	*t*	*df*	Sig.	*d*	Sexual dimorphism (%)
HHTD	Modern	40.9	3.7					12.9
	Coimbra	39.4	2.0	3.350	62	.001	.53	12.2
HHVD	Modern	44.4	4.2					13.5
	Coimbra	42.4	2.2	4.075	68	< .001	.63	11.8
HEB	Modern	57.4	5.9					14.8
	Coimbra	56.6	3.4	1.138	69	.259		14.1
FHTD	Modern	43.8	3.9					11.9
	Coimbra	42.8	2.3	2.172	75	.033	.32	10.8
FHVD	Modern	44.3	3.7					11.8
	Coimbra	43.2	2.3	2.507	75	.014	.37	10.8
TML	Modern	52.1	3.9					9.1
	Coimbra	52.0	2.6	.125	77	.901		9.8
CML	Modern	78.2	6.1					9.5
	Coimbra	75.5	4.2	3.767	74	< .001	.52	8.8

Key: humeral head transverse diameter (HHTD), humeral head vertical diameter (HHVD); humeral epicondylar breadth (HEB); femoral head transverse diameter (FHTD); femoral head vertical diameter (FHVD); talar maximum length (TML); and calcaneal maximum length (CML).

The application of cut-off points from the Coimbra references to the modern sample gave quite varied results (Table 4). Four standard measurements provided correct sex classifications higher than 80% in both females and males – HHVD, HEB, FHTD and FHVD. The HHTD and the CML provided poor results regarding the sex estimation of females while the opposite was found for males. Finally, the Coimbra reference for the TML was poorly successful in both female and male samples. Overall, all classification rates were lower than those reported originally by Silva (1995) and Wasterlain and Cunha (2000).

When a more conservative procedure was adopted, correct classification improved in most cases (Table 5). A category of undeterminable bones was built based on the 99% confidence interval of the standard error of the sample. Therefore, this value was multiplied by 2.58 and the resulting value was in turn added and subtracted to the mean to calculate the bounds of the undeterminable category. Consequently, only measurements outside this range were used for sex estimation. This procedure allowed for better classification rates in all standard measurements except for the HHVD in both sexes, the FHVD in the female case and the CML in the male case. Despite this overall improvement in accuracy, the males were still systematically more often correctly estimated than females in all standard measurements excepting for the HEB.

Table 4. Correct sex classification (%) on the modern sample resulting from the application of the reported sex discriminating cut-off point of the Coimbra references.

	Females		Males		Total	
Standard Measurement	n	Correct classification	n	Correct classification	N	Correct classification
HHTD	28	78.6%	35	91.4%	63	85.7%
HHVD	31	80.7%	38	94.7%	69	88.4%
HEB	32	84.4%	38	86.8%	70	85.7%
FHTD	35	80.0%	41	82.9%	76	81.6%
FHVD	35	80.0%	41	85.4%	76	82.9%
TML	37	64.1%	37	78.4%	78	76.9%
CML	39	61.5%	36	86.1%	75	73.3%

Key: humeral head transverse diameter (HHTD), humeral head vertical diameter (HHVD); humeral epicondylar breadth (HEB); femoral head transverse diameter (FHTD); femoral head vertical diameter (FHVD); talar maximum length (TML); and calcaneal maximum length (CML).

Table 5. Sex classification rates on the modern sample resulting from the application of the reported sex discriminating cut-off point of the Coimbra references but taking into account a category of undetermined individuals (Undet) based on the 99% confidence interval of the standard error of the mean. The classification rates thus refer only to determinable individuals.

	Females			Males			Total		
Standard Measurement	n	Undet	Correct classification	n	Undet	Correct classification	N	Undet	Correct classification
HHTD	28	3	84.0%	35	2	93.9%	63	5	89.7%
HHVD	31	4	77.8%	38	1	94.6%	69	5	87.5%
HEB	32	3	89.6%	38	1	89.2%	70	4	89.4%
FHTD	35	4	83.9%	41	4	89.2%	76	8	86.8%
FHVD	35	0	80.0%	41	2	89.7%	76	2	85.2%
TML	37	4	78.4%	37	1	80.1%	78	5	79.5%
CML	39	7	68.8%	36	0	86.1%	75	7	77.9%

Key: humeral head transverse diameter (HHTD), humeral head vertical diameter (HHVD); humeral epicondylar breadth (HEB); femoral head transverse diameter (FHTD); femoral head vertical diameter (FHVD); talar maximum length (TML); and calcaneal maximum length (CML).

Discussion

Overall, the data suggest that a positive secular trend affected the dimensions of several metric features of the Portuguese population and their respective sexual dimorphism. The only exceptions were the HEB and the TML. Both did not show any statistical difference between the modern sample and the Coimbra references. The TML even presented a smaller sexual dimorphism in the modern sample than in the sample assembled by Silva (1995), which, although bearing in mind that the difference is not significant, is somewhat unexpected given that a positive secular trend should in theory result in larger sexual dimorphism (Kuh et al., 1991; Cole, 2000). Apparently, secular changes differentially affected the skeleton of Portuguese ancestry.

Significant secular changes led to an important consequence – the sex estimation power of the Coimbra references was clearly diminished in some of the standard measurements when compared to the previously reported classification rates (Silva, 1995; Wasterlain and Cunha, 2000). The features that did not present this significant secular change – HEB and TML – provided distinct results. In the case of the HEB, sex estimation was quite accurate in both females and males from the modern sample. In fact, this feature was the one allowing for the best performance, since the evaluation of other features did not permit equal accuracy in both sexes or resulted in lower accuracy rates. This is not surprising since no significant secular changes were found for the HEB. However, opposite results were obtained for the TML – besides being quite unequal, the accuracies obtained in both sexes were quite low. This is rather unexpected since the means of the modern sample and the Coimbra references were very similar.

The sexually unequal and generally low accuracy scores indicate that an update must be carried out in order to obtain references that are more adapted to the characteristics of the current Portuguese population. This is especially important for forensic contexts, since implications of inaccurate sex estimations are more serious than in archaeological contexts. The need of new references is even more critical if we take into consideration that the modern sample was composed of very aged individuals. Secular changes were already clearly patent in this sample but we may extrapolate that their effect in younger individuals may be even greater, taking into consideration the substantial Portuguese secular increase in stature during the 20th century (Padez and Johnston, 1999; Padez, 2003 and 2007; Conceição et al., 2012). Possibly, the results from this research cannot adequately replace some of the Coimbra references due to the small sample size and its age biased composition.

One way of working around the problem of using methods across populations, something that is usually carried out when more specific references are not available, is to take a conservative approach. As seen in this research, the adoption of an undeterminable category generally resulted in highest correct classifications. However, the approach here used did not completely solve the problem since it did not sufficiently improve the sex estimation performance based on the features of the tarsal bones in order to endorse its use in recent skeletal remains. Therefore, more conservative approaches are recommendable. Those based in probabilistic sex estimation have had good results previously (Murail et al., 2005; Navega et al., 2012).

Conclusion

The effect of secular changes on the reliability of metric methods was clearly demonstrated in this investigation. Metric methods have an expiry date and constant monitoring is required to confirm that they still have enough power to sex estimate unknown individuals. When reduced, this may not forcibly imply that the method is useless though. Sometimes, sex estimation of individuals based on out-of-date references is necessary because more adequate references are not always available. In this case, more conservative interpretations of the results are required. One aspect that is clearly improved by tests such as the one here presented refers to the report of the probability of an estimation to be correct. Its calculation is dependent on the percentage of correct classifications that is provided by a given method, so the present paper offers new variables for a more accurate calculation of the chance that the sex of a modern unknown individual is being correctly estimated (For more details, check: Klepinger, 2006; Murty and Devy, 2012; Navega et al., 2012). In addition, the raw data are presented in the appendices (Tables A1 and A2)

In the particular case of the Coimbra references, the accuracy resulting from their application to a modern sample was quite varied from feature to feature. Although additional research should be carried out to confirm these conclusions, the adoption of the Coimbra references focusing on the tarsal bones seems to be more problematic and extra caution should be used when applying them.

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Table A1. Raw data of the measurements carried out in the modern sample of males (in mm).

#	Age	Date of death	HHTD	HHVD	HEB	FHTD	FHVD	TML	CML
1	77	2001	45.75	49.22	62.31	50.35	50.73	55.26	92.23
2		1999	44.31	46.43	59.43	47.56	49.17	56.56	82.88
3		1996	42.71	44.3	64.42	44.71	46.02	55.23	85.72
4	59	2002	46.18	51.75	66.42	52.49	51.94	57.68	87
5		1999	42.86	44.62	62.73	45.16	46.53	53.73	82.09
6		2000		50.52	66.5	49.42	49.63	57.08	85.7
7	27	2002	47.39	50.51	66.45	49.5	49.18	61	85.36
8	74	2002	44.58	50.8	61.25	47.78	47.41	53.29	82.81
9		1993	39.48	42.86	57.47	42.72	45.04	50.75	71.98
10		1999	43.29	47.78	61.22	46.45	47.57	56.56	82.88
11	70	2005	43.54	47.57	58.56	44.31	44.67	50.26	76.42
12	90	1999		51.45	62.47	48.14	48.64	57.19	82.68
13		1998	50.57	51.94		52.26	50.56		
14		1996		40.27	53.52	40.87	42.03	49.82	73.29
15		2003	43.5	47.47	56.58	45.65	47.05	54.63	81.85
16		2001	46.33	48.01	58.23	47.39	47.91	55.16	85.24
17	81	2002	36.47	42.45	55.77	40.79	42.16	48.17	71.73
18		2003			62.07	46.25	45.99	53.65	77.3
19		2003	45.91	52.94	69.04	46.95	48.53	59.71	87.27
20		1998	40.6	44.7		44.15	45.52	52.6	78.85
21		2003			54.6	39.97	41.12	48.71	67.61
22	95	2003	46.84	50.86	63.07	48.51	48.47	58.45	83.77
23	38	2000	40.61	44.13	58.72	44.11	44.76		
24		2003	45.18	48.49	65.08	46.09	46.72	56.83	84.18
25		2003	43.42	45.63	59.13	45.32	45.68	51.88	85.22
26	89	2003	41.97	45.54	65.19	47.05	47.88		
27		2003	42.89	47.09	62.89	48.51	48.31	53.81	84.3
28		2003	47.57	52.08	65.51	49.93	50.79	59.12	89.27
29		2005				43.03	44.14	55.3	
30		2001	43.84	48.43	63.15	47.76	46.97	55.02	83.87
31	76	2003	42.91	45.47	60.95	46.89	47.07	56.78	83.69
32	40	1995	43.79	46.19	66.28	47.42	47.22	57.31	90.62
33		2003	40.78	48.2	65.13	47.05	46.39		
34		2004	41.66	43.94	58.92	42.69	43.09	53.99	83.06
35		2003	44.85	47.57	64.2	45.37	46.4	56	81.21
36	82	2001	41.2	45.05	59.07	44.97	45.51	53.39	80.06
37	78	1997	39.37	45.07	63.4	42.68	42.96	49.29	80.67
38	71	1993	40.76	48.98	61.45	48.17	47.34	54.9	80.42
39	55	2003	46.43	50.65	63	50.34	50.51	57.33	86.88
40		2001	44.53	46.25	64.39	49.42	50.02	56.48	87.38
41		1997	38.14	40.34	52.36	42.02	42.35	50.33	73.63

Key: humeral head transverse diameter (HHTD), humeral head vertical diameter (HHVD); humeral epicondylar breadth (HEB); femoral head transverse diameter (FHTD); femoral head vertical diameter (FHVD); talar maximum length (TML); and calcaneal maximum length (CML).

Table A2. Raw data of the measurements carried out in the modern sample of females (in mm).

#	Age	Date of death	HHTD	HHVD	HEB	FHTD	FHVD	TML	CML
42	71	2003	38.3	43.39	55.32	41.22	42.17	51.53	76.25
43	78	2001	38.41	41.46	47.9			52.9	79.31
44	82	1991						53.36	76.95
45	76	2002						47.47	67.31
46	75	2002	38.14	41.5	58.28	41.74	41.94	51.16	79.71
47	91	2004	39.93	44.81	56.85	43.41	43.71	53.43	79.83
48	67	2002	39.89	40.54	55.86	41.34	41.63	48.68	70.89
49	99	2004			55.76	41.05	42.21	51.13	69.82
50	70	1998	35.48	37.55	51.43	39.05	40.29	44.03	70.68
51	80	1991						50.98	75.67
52	54	2002	40.37	44.3	53.52	43.84	44	53.65	73.7
53	48	2003	36.19	41.87	47.11	41.22	41.39	48.23	75.04
54	85	1998			56.44	43.38	44.52	55.95	84.43
55	83	2003	38.32	43.55	48.43	41.32	42.07	47.15	73.38
56	92	2003	39.3	42.05	47.87			53.1	77.99
57	78	1990		38.07	51.25	40.94	41.4	47.84	71.09
58		2003	37.92	43.06	46.91			47.22	70.67
59	79	2003	37.24	39.62	45.49	40.73	40.03	49.89	71.73
60		2005				43.03	44.14	53.3	
61		2005	39.7	39.6	55.58	41.4	40.67	48.58	79.07
62		1992	36.22	39.23		39.1	38.47	46.08	70.68
63		2003			49.43	39.06	39.63	50.27	74.79
64		2003		40.99	53.61	38.93	40	50.19	76.3
65	92	2003	39.46	40.1	51.32	42.86	42.25	47.67	70.37
66	71	2001				41.65	42.14	52.25	74.51
67	79	1998	38.07	42.08	50.89	42.49	41.96	50	75.93
68	78	2003		45.57	57.49	44.23	44.16	50.19	
69		2000	35.22	39.54	50	38.95	39.06	46.82	72.01
70	76	2003	37.8	41.92	55.2	35.17	40	47.85	72.45
71	71	1999	36.49	39.58	51.42	38.63	39.2	46.84	72.3
72	73	2003	38.4	39.62		36.96	37.65	47.52	70.71
73	30	2005	40.15	41.98	51.87	41.35	41.43	51.84	75.97
74	78	2003	36.71	39.7		41.75	42.04	47.92	74.09
75		1999	35.39	38.08	50.43	37.73	37.82	45.05	73.61
76	98	2000	37.35	40.07		40.55	41.54	46.87	69.33
77		2000	35.49	37.73	49.37	35.59	36.2	45.27	68.91
78		1991	35.97	39.88	53.52	39.86	39.98	50.35	73.72
79		2000	38.59	41.98	56.83	42.3	42.58	54.79	79.29
80	87	2003			55.71	45.93	45.78	48.33	81.74
81	57	2004	38.57	39.81	50.89	39.53	39.32	49.35	73.89
82		2003			57.54	42.82	44.59	52.03	78.45

Key: humeral head transverse diameter (HHTD), humeral head vertical diameter (HHVD); humeral epicondylar breadth (HEB); femoral head transverse diameter (FHTD); femoral head vertical diameter (FHVD); talar maximum length (TML); and calcaneal maximum length (CML).