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Sex determination from the head of the femur of South African whites and blacks

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Abstract

The current practice whereby criminals dismember the remains of their victims in an attempt to make their identification difficult requires that simple methods of sex determination from fragmented skeletal remains are available to forensic anthropologists and skeletal biologists. The head of the femur is an example of such bone fragments. Identification and demarking points have been derived from the diameters of the head of the femur and used to determine the sex of individuals. It has been shown, however, that the numerical values of these parameters that permit sex identification vary between races. The objectives of the present study were therefore to establish the standard numerical values of the identification and demarking points for sex determination in South African whites and blacks and to see if these standards are different in the two races. A total of 520 femurs of white (160 males and 100 females) and black (160 males and 100 females) South Africans were obtained from the Raymond Dart Skeletal Collection in the Department of Anatomical Sciences of the University of the Witwatersrand, Johannesburg, South Africa. The vertical and transverse diameters of the heads of the femurs were measured by means of a stainless steel vernier caliper. Identification and demarking points were derived from the values of these diameters. The head diameter identification point and demarking point were found to be sexually dimorphic in both white and black South Africans. The mean head diameter of the male femur was significantly greater than the mean head diameter of the female femur in both population groups (significant at $P < 0.001$). These values were correspondingly greater in the white than the black population. The numerical values of the male identification and demarking points were higher than the corresponding female values in the two population. In both sexes, these values were greater in the whites than the blacks South Africans. It is concluded that the diameters of the head of the femur and the identification and demarking points that are derived from them are sexually dimorphic in South African white and black populations. However, the numerical values of these sex-determining bone parameters defer between the two population groups. Therefore, it is necessary to determine race-specific standards of these parameters.

Keywords: Sex determination; Femoral head; South Africans

1. Introduction

When only skeletons are available for sex determination, the forensic anthropologist may use simple methods that are based on the measurement of various bone parameters. The ability to determine sex from isolated and fragmented bones is of particular relevance and importance in South Africa where criminals sometimes cut the remains of their victims in pieces in an attempt to make their identification difficult. In these circumstances, the forensic anthropologist and

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skeletal biologist may have to rely on the measurement of sexually dimorphic parameters of available bone fragments. For this purpose, measurements of different parts of the femur including its length [1], bicondylar breadth [2], angle of torsion [3], collo-diaphyseal angle [4], neck diameter [5], head diameter [1,6–9] and spherical index of the head [10] may be used.

The means of the vertical and transverse diameters of the head of the male femur have been shown to be significantly greater than the corresponding diameters of the female femur from the same population [6,8–10]. However, there is a great deal of overlap between the male and female values with the result that a large number of bones in the overlap zone cannot be assigned to either sex. In an attempt to improve the accuracy of sex determination from the head of the femur, identification and demarking points [6,8] were derived from these diameters and used for the purpose of sex determination. While these authors agree that identification and demarking points are useful in sex determination, the numerical values of these points that form the criteria for sex determination appear to vary between races [6,8,9]. For example, the identification point of the head of the male femur is lower in North Indians (45 mm) and Caucasians (45.5–48 mm) than in Nigerians (50–53.5 mm) [6,8–12]. Demarking points also differ between Indians and eastern Nigerians [8,10]. Therefore, if the head of the femur is to be used for sex determination, a standard data of the identification and demarking points may have to be determined for different races and regional groupings.

Although, the mean maximum diameter of the head of the femur has been used for sex determination in whites South African [1], the identification and demarking points have not been used for this purpose in South African skeletons. Therefore, the objectives of this study were to establish standards for the use of identification and demarking points for sex determination in South African whites and blacks and to see if these standard differ between the two races.

2. Materials and methods

A total of 520 femurs of South African whites of European origin (160 males and 100 females) and blacks (160 males and 100 females) were obtained from the Raymond Dart Skeletal Collection in the Department of Anatomical Sciences, University of the Witwatersrand, Johannesburg, South Africa. The bones that showed any form of morphological abnormality, deformity or abrasions of the articular surfaces and margins of the heads were excluded from the study. Femurs that showed evidence of previous fracture of the neck as well as those that were still growing, as evidenced by non-fusion of the epiphyses to the diaphyses, were also excluded from the study. The mean age of the bones was 67.3 years (32–93) for white males, 69.8 years (21–95) for white females, 43.8 years (20–90) for black males and 43.1 years (21–96) for black females.

The vertical and transverse diameters of the heads of the femurs were measured directly on the bones by using a stainless steel vernier caliper [13]. The data were analyzed using the Microsoft Excel statistical program. Students' *t*-test was performed for the differences of the means of femoral head diameters using the Epi-Info statistical package (WHO/CDC). Identification and demarking points for sex determination were determined using the method of Jit and Singh [14]. Femurs with head diameters above the male identification and demarking point values were identified as male bones while those with head diameters below the female identification and demarking point values were those of females.

3. Results

The range and mean values of the femoral head diameters and the identification and demarking points for South African whites and blacks are shown in Tables 1–3 and Figs. 1 and 2.

3.1. Femoral head diameters

Whites — there were no statistically significant side differences between the diameters in both sexes (Table 1; Fig. 1). Table 3 shows that the mean vertical and transverse head diameters of male femurs (48.40 and 46.73 mm, respectively) were significantly greater (at $P < 0.001$) than those of female femurs (42.32 and 40.96 mm).

Blacks — no significant side differences were seen in the male and female values (Table 2; Fig. 2). Table 3

Table 1
Identification and demarking points for sex determination in South African whites

	Vertical femoral head diameter				Transverse femoral head diameter			
	Right		Left		Right		Left	
	Male	Female	Male	Female	Male	Female	Male	Female
N	160	100	160	100	160	100	160	100
Range (mm)	43.00–56.00	36.65–48.70	42.85–57.90	36.40–48.75	40.20–59.00	35.35–48.10	41.70–54.35	35.45–48.00
Mean (mm)	48.47[a]	42.36	48.40[a]	42.28	46.61[b]	40.92	46.85[b]	41.00
S.D. (mm)	2.61	2.37	2.57	2.40	2.82	2.53	2.51	2.51
S.E. (mm)	0.206	0.237	0.203	0.240	0.223	0.253	0.198	0.251
IP (mm)	48.70	43.00	48.75	42.85	48.10	40.20	48.00	41.70
Calculated range (mm)	40.64–56.30	35.25–49.47	40.69–56.11	35.08–49.48	38.15–55.07	33.33–48.51	39.32–54.38	33.47–48.53
DP (mm)	49.47	40.64	49.48	40.69	48.51	38.15	48.53	39.32

[a] Significantly higher (at $P < 0.001$) than the corresponding female vertical diameter.
[b] Significantly higher (at $P < 0.001$) than the corresponding female transverse diameter. S.D. — standard deviation; S.E. — standard error; IP — identification point; DP — demarking point.

Table 2
Identification and demarking points for sex determination in South African blacks

	Vertical diameter				Transverse diameter			
	Right		Left		Right		Left	
	Male	Female	Male	Female	Male	Female	Male	Female
N	160	100	160	100	160	100	160	100
Range (mm)	38.60–50.30	35.10–44.80	38.45–51.60	34.60–45.85	37.90–49.95	34.45–44.90	36.85–50.20	34.50–46.10
Mean (mm)	44.57[a]	39.97	44.45[a]	39.64	44.20[b]	39.33	44.20[b]	39.20
S.D. (mm)	2.45	2.01	2.50	2.21	2.52	2.08	2.58	1.97
S.E. (mm)	0.194	0.201	0.198	0.221	0.199	0.208	0.204	0.197
IP (mm)	44.80	38.60	45.85	38.45	44.90	37.90	46.10	36.85
Calculated range (mm)	37.22–51.92	33.94–46.00	36.95–51.95	33.01–46.27	36.64–51.76	33.09–45.57	36.46–51.94	33.29–45.11
DP (mm)	46.00	37.22	46.27	36.95	45.57	36.64	45.11	36.46

[a] Significantly higher (at $P < 0.001$) than the corresponding female vertical diameter.
[b] Significantly higher (at $P < 0.001$) than the corresponding female transverse diameter. S.D. — standard deviation; S.E. — standard error; IP — identification point; DP — demarking point.

Table 3
Comparison of mean femoral head parameters for white and black South African populations[a]

	Diameter (mm)				Identification point (mm)				Demarking point (mm)			
	Male		Female		Male		Female		Male		Female	
	Vertical	Transverse	Vertical	Transverse	Vertical	Transverse	Vertical	Transverse	Vertical	Transverse	Vertical	Transverse
Whites	48.40 a	46.73 b	42.32	40.96	48.73	48.05	42.93	40.95	49.48	48.52	40.67	38.74
Blacks	44.51 a	44.20 b	39.81	39.27	45.33	45.50	38.53	37.38	46.14	45.34	37.09	36.55

[a] Vertical and transverse femoral head diameters, identification points and demarking points are means of left and right values. Here, a and b are significantly higher (at $P < 0.001$) than the corresponding female diameters.

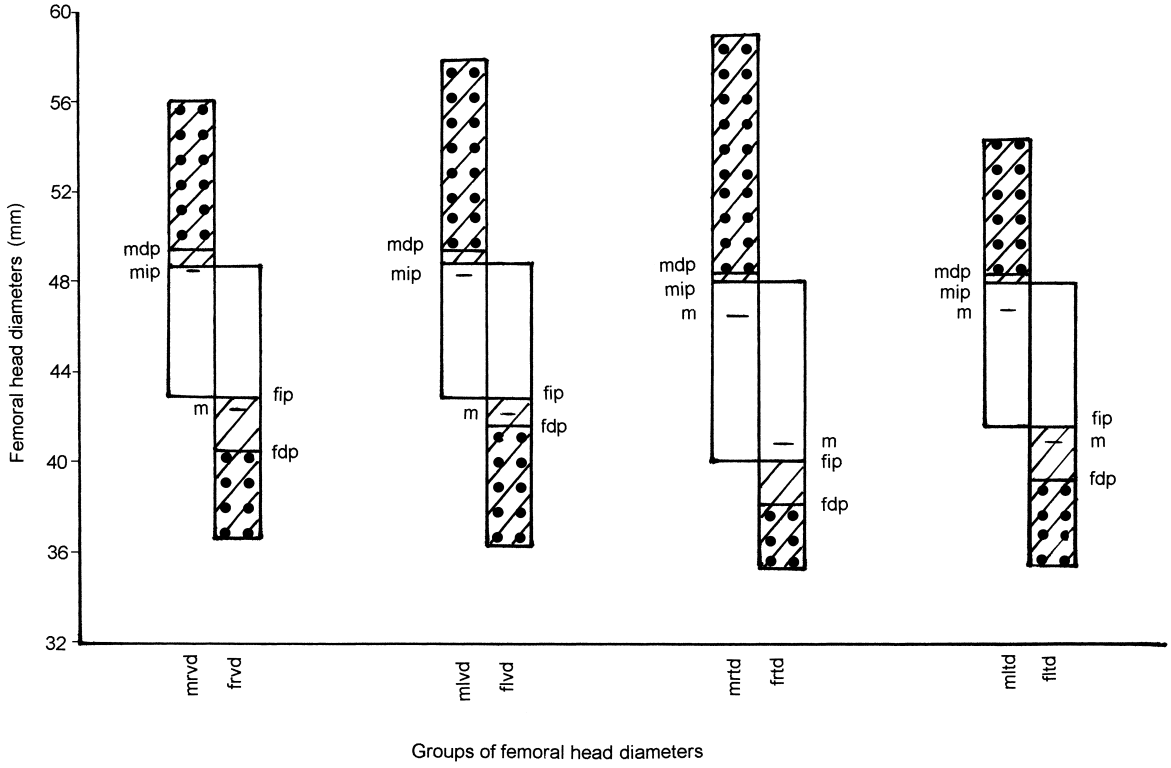

Fig. 1. Bar chart showing the ranges of femoral head diameters of male and female South African whites. Here, mrvd: male right vertical diameter; frvd: female right vertical diameter; mlvd: male left vertical diameter; flvd: female left vertical diameter; mrtd: male right transverse diameter; frtd: female right transverse diameter; mltd: male left transverse diameter; fltd: female left transverse diameter; mip: male identification point; fip: female identification point; mdp: male demarking point; fdp: female demarking point; *m*: mean diameter and refers to the short horizontal line inside the box. Hatched area represents segment of diameter range for which identification point could identify the sex of femur, and spotted area represents segment of the diameter range for which demarking point could identify the sex of femur.

also shows that the male mean vertical (44.51 mm) and transverse (44.20 mm) head diameters were significantly greater (at $P < 0.001$) than those of the females (39.81 and 39.27 mm, respectively).

3.2. Identification points

Whites — in both sexes, there were no side differences in the values of the identification points (Table 1 and Fig. 1). Table 3 shows that the male sex identification points (48.73 mm for vertical and 48.05 mm for transverse diameter) were greater than the values for the female (42.93 mm for vertical and 40.95 mm for transverse diameter).

Blacks — the identification points were smaller on the right than on the left side in males, but greater on the right side in females, although these differences were not significant (Table 2; Fig. 2). The male vertical (45.33 mm) and transverse (45.50 mm) identification points were higher than the corresponding female values of 38.53 and 37.38 mm (Table 3).

3.3. Demarking points

Whites — the values of the male demarking points (49.48 and 48.52 mm for vertical and transverse diameters) were higher than those of the females (40.67 and 38.74 mm, respectively) and showed no significant side differences in both sexes (Tables 1 and 3; Fig. 1).

Blacks — there were no significant side differences between these values (Table 2; Fig. 2). The male demarking points (46.14 mm for vertical and 45.34 mm for transverse diameters) were higher than

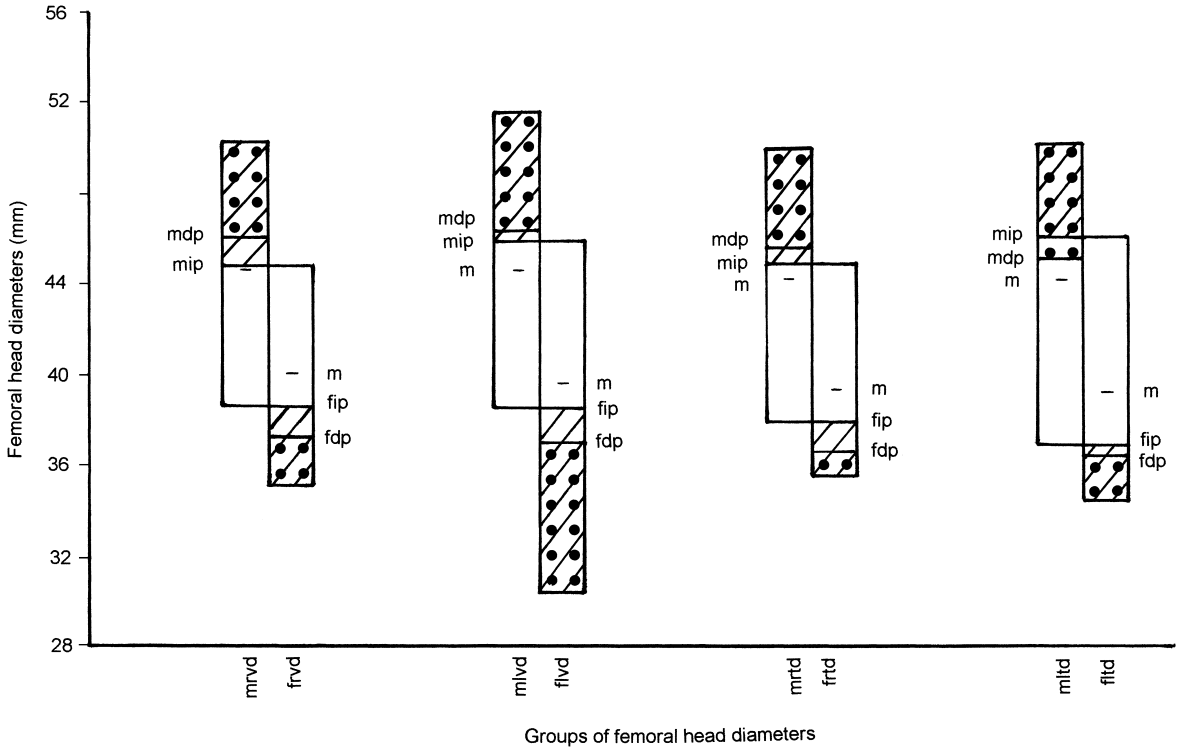

Fig. 2. Bar chart showing the ranges of femoral head diameters of male and female South African blacks. Here, mrvd: male right vertical diameter; frvd: female right vertical diameter; mlvd: male left vertical diameter; flvd: female left vertical diameter; mrtd: male right transverse diameter; frtd: female right transverse diameter; mltd: male left transverse diameter; fltd: female left transverse diameter; mip: male identification point; fip: female identification point; mdp: male demarking point; fdp: female demarking point; *m*: mean diameter and refers to the short horizontal line inside the box. Hatched area represents segment of diameter range for which identification point could identify the sex of femur, and spotted area represents segment of the diameter range for which demarking point could identify the sex of femur.

the corresponding female values of 37.09 and 36.55 mm, respectively (Table 3).

4. Discussion

The diameters of the head of the femur and the identification and demarking points that can be derived from them show distinct differences between males and females and can be used as sex-determining parameters. In the white population, the vertical head diameter which is similar in value to that obtained by Steyn and İşcan [1] for the South African white population, and the identification and demarking points have higher numerical values in male than in females. The pattern is similar in the black population except with respect to the male identification point where the value that is derived from the transverse diameter is higher than the one from the vertical diameter. But the difference between the two values is not significant. The numerical value of the male demarking point is usually greater than the corresponding identification point while the value of the female demarking point is lower than that of the corresponding identification point. This pattern is seen in the femurs of South African whites and blacks except in the black male where the demarking point derived from the transverse diameter is lower than the corresponding identification point. This may be due to the wide range of transverse head diameters in the female femurs that were used in determining the male demarking point (Table 2; Fig. 2).

The mean diameter of the head of the femur and the identification and demarking points in both sexes are

of higher numerical values in South African whites than their black counterparts. This phenomenon indicates the existence of racial differences in these bone parameters.

The high degree of side differences in morphological features of the femur that Macho [15] observed in southern African femurs were not borne out in this study of the femoral head diameters and their identification and demarking points. Therefore, standard data for white and black South Africans may be determined from the means of left and right head diameters as in Table 3 or the vertical diameter alone which lends itself to a greater consistency of measurement than the transverse diameter.

5. Conclusion

The diameters of the head of the femur and the identification and demarking points that are derived from them can be used for sex determination. This is of advantage when the complete bone is not available for use. The numerical values of these sex-determining bone parameters show differences between the whites and black South African. This confirms previous findings that a data that is obtained in one racial grouping is not necessarily applicable to other races. Therefore, race-specific numerical values of these parameters need to be determined.

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