Sexing accuracies using proximal and middle phalanges of the hand in a modern South African sample

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Introduction

Forensic anthropologists include a number of demographic characteristics when analyzing human remains which includes determination of sex. Hand bones are usually excluded from studies on sexual dimorphism due to their relatively small size and often poor preservation. However, Scheuer and Elkington (1993) have shown that metacarpals and the first proximal phalanx are as sexually dimorphic as the long limb bones. These authors reported sexing accuracies for metacarpals ranging between nearly 74.0% to 79.0% and 74.0% to 94.0% for probable and actual accuracies. Their results for the first proximal phalanx were reported as 74.0% and 78.0% for probable and actual correct sex determination respectively. Falsetti (1995), reported similar percentages for metacarpals. No studies on the use of the proximal (Figure 1) and middle (Figure 2) phalanges of the hands in a South African population have been done.

Aims

The aim of this study was to determine if the dimensions of the proximal (Fig 1) and middle (Fig 2) phalanges of the human hand can be used to determine sex of an unknown individual through the use of discriminant function formulae.

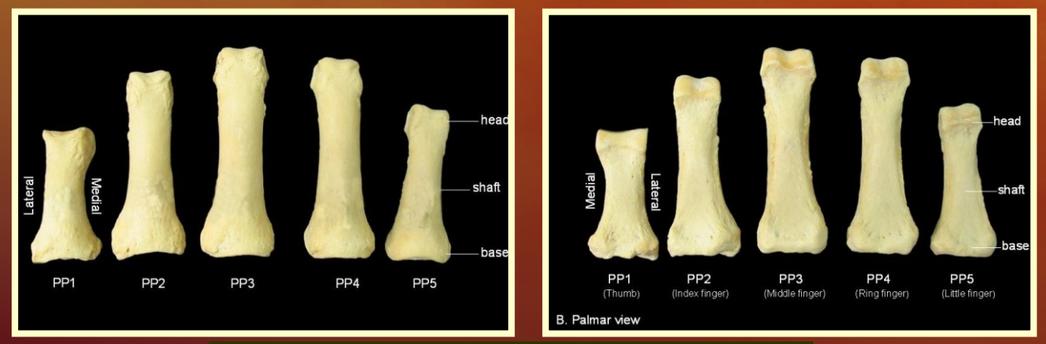


Figure 1: Dorsal (A) and palmar (B) views of proximal phalanges (PP) 1 to 5 of the right (R) hand.

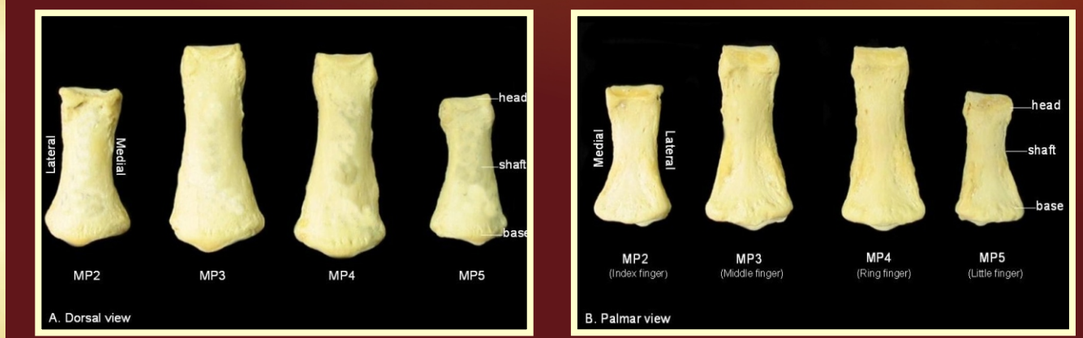


Figure 2: Dorsal (A) and palmar (B) views of middle phalanges (MP) 2 to 5 of the right (R) hand.

Materials and Methods

A total of 200 sets of hand bones from each sex-population group (50 black males, 50 black females, 50 white males and 50 white females) were used. These hands were obtained from the Pretoria Bone Collection in the Department of Anatomy. The age of the individuals ranged from 21 to 81 years. A total of seven measurements were taken on each hand bone (Figures 3a,b). For purposes of statistical analyses, data from the two population groups were pooled.

All measurements were recorded to the nearest 0.01mm using a digital caliper. A discriminant function analysis was done using SPSS version 11.5. This analysis was carried out using all seven measurements for a stepwise procedure, after which only the first selected variable was entered into a direct analysis. Canonical discriminant function coefficients were obtained for each measured variable.

Figure 3a: Palmar view of the second proximal phalanx showing the length and mediolateral (m-l) measurements of the head, midshaft and base.

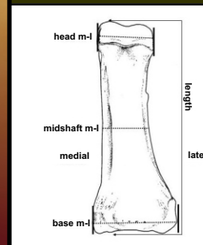
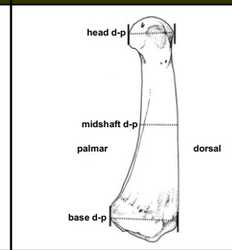


Figure 3b: Lateral view of the second proximal phalanx showing the length and dorsopalmar (d-p) measurements of the head, midshaft and base.



Results

Descriptive statistics comparing mean values of all seven dimensions for each phalanx showed that the dimensions for each bone were significantly greater ($p<0.01$) in males than in females. A discriminant function analysis was then done.

Results obtained from the discriminant function analysis for all proximal phalanges (PP) showed that only three of the seven variables were selected for the first (PP1) and second (PP2) proximal phalanges in a stepwise analysis. A direct analysis was then run on the best selected variable for these bones, namely anteroposterior midshaft of PP1 and mediolateral midshaft of PP2. Only two variables were selected for the third, fourth and fifth proximal phalanges. In these bones, the anteroposterior base for PP3 and PP4 and the mediolateral midshaft of PP5 were the best variables.

Results obtained from the discriminant function analysis for all middle phalanges showed that only three of the seven variables were selected for the second middle phalanx in a stepwise analysis. A direct analysis was then run on the best variable for this bone, namely, the anteroposterior measurement of the base. Only two variables were selected for the third, fourth and fifth middle phalanges. In these bones, the mediolateral measurement was the best variable which was then incorporated into the direct analysis.

Table 1 indicates the classification accuracy for proximal phalanges. The overall accuracies are high. In males, these accuracies for the stepwise analysis range from 80.6% to 84.0% and for the direct analysis it is 74.5% to 85.0%. For females the ranges are 85.9% to 88.8% and 86.6% to 88.9% for the stepwise and direct analyses respectively. These accuracies dropped slightly on cross-validation.

Table 2 indicates the classification accuracy for middle phalanges. The overall accuracies are high. In males, these accuracies for the stepwise analysis range from 77.6% to 85.0% and for the direct analysis it is 71.7% to 79.2%. For females the ranges are 85.4% to 86.7% and 83.3% to 85.4% for the stepwise and direct analyses respectively. These accuracies dropped slightly on cross-validation.

Table 1: Sexing accuracy using the proximal phalanges 1 to 5. Percentage of correct group membership and cross-validation.

Function		N (Total)	Male Count	%	Female Count	%	Average Accuracy
Proximal phalanx 1 Stepwise	Original	198	84/100	84.0	87/98	88.8	86.4
	Cross-validated	198	84/100	84.0	86/98	87.8	85.9
Direct midshaft ap	Original	198	85/100	85.0	87/98	88.8	86.9
	Cross-validated	198	85/100	85.0	87/98	88.8	86.9
Proximal phalanx 2 Stepwise	Original	197	79/98	80.6	85/99	85.9	83.2
	Cross-validated	197	79/98	80.6	85/99	85.9	83.2
Direct midshaft ml	Original	197	73/98	74.5	88/99	88.9	81.7
	Cross-validated	197	73/98	74.5	88/99	88.9	81.7
Proximal phlalanx 3 Stepwise	Original	198	81/100	81.0	87/98	88.8	84.8
	Cross-validated	198	80/100	80.0	86/98	87.8	83.8
Direct base ap	Original	198	82/100	82.0	86/98	87.8	84.8
	Cross-validated	198	82/100	82.0	86/98	87.8	84.8
Proximal phalanx 4 Stepwise	Original	198	81/100	81.0	86/98	87.8	84.3
	Cross-validated	198	80/100	80.0	86/98	87.8	83.8
Direct base ap	Original	198	77/100	77.0	85/98	86.7	84.8
	Cross-validated	198	77/100	77.0	85/98	86.7	83.3
Proximal phalanx 5 Stepwise	Original	193	81/97	83.5	83/96	86.5	85.0
	Cross-validated	193	81/97	83.5	83/96	86.5	85.0
Direct midshaft ml	Original	194	78/97	80.4	84/97	86.6	83.5
	Cross-validated	194	77/97	79.4	84/97	86.6	83.0

Table 2: Sexing accuracy of middle phalanges 2 to 5 of South Africans. Percentage of correct group membership and cross-validation.

Function		N (Total)	Male Count	%	Female Count	%	Average Accuracy
Middle phalanx 2 Stepwise	Original	194	76/98	77.6	82/96	85.4	81.4
	Cross-validated	194	76/98	77.6	81/96	84.4	80.9
Direct base ap	Original	194	71/98	72.4	80/96	83.3	77.8
	Cross-validated	194	71/98	72.4	80/96	83.3	77.8
Middle phalanx 3 Stepwise	Original	198	85/100	85.0	85/98	86.7	85.9
	Cross-validated	198	85/100	85.0	85/98	86.7	85.9
Direct midshaft ml	Original	198	79/100	79.0	83/98	84.7	81.8
	Cross-validated	198	79/100	79.0	83/98	84.7	81.8
Middle phlalanx 4 Stepwise	Original	195	77/99	77.8	83/96	86.5	82.1
	Cross-validated	195	77/99	77.8	83/96	86.5	82.1
Direct midshaft ml	Original	195	71/99	71.7	82/96	85.4	78.5
	Cross-validated	195	70/99	70.7	82/96	85.4	77.9
Middle phalanx 5 Stepwise	Original	191	80/96	83.3	82/95	86.3	84.8
	Cross-validated	191	79/96	82.3	82/95	86.3	84.3
Direct midshaft ml	Original	191	76/96	79.2	80/95	84.2	81.7
	Cross-validated	191	76/96	79.2	80/95	84.2	81.7

Conclusions

Average classification accuracies for proximal phalanges ranged from 83.2% to 86.4% and 81.7% to 86.9% for stepwise and direct analyses with the highest accuracies obtained for PP1 and PP3. Average classification accuracies for middle phalanges ranged from 81.4% to 85.9% and 77.8% to 81.8% for stepwise and direct analyses with the highest accuracies obtained for MP3. In conclusion, these results compare with those of previous studies indicating that these bones can be used to determine sex.

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