The application of FORDISC 3.0 to South African crania

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Introduction

The demographic structure of South Africa is highly heterogeneous and is constantly changing with increasing immigration from African countries such as Somalia, Sudan and Zimbabwe, to name but a few. Within this ever increasing melting pot of genes and social identities, the forensic anthropologist has become less confident in deciphering the ancestry or sex of an unknown person. Unlike the determination of sex for which two possible genetic outcomes exist, certain phenotypic features such as the presence of an Inca bone or sharp nasal spines may no longer be associated to a particular ancestry, or race group, that our anthropological forefathers suggested them to have belonged. In this world wide situation of rapidly changing demographic structures, the forensic anthropologist must add to and evaluate their current morphological and osteometric tool kit.

The question has arisen as to whether anthropologists can use additional osteometric databases, such as FORDISC, to assist in evaluating ancestry and sex from South African skeletal remains. FORDISC is an analytical program distributed by the University of Tennessee. It employs discriminant analysis to assist forensic anthropologists in their assessment of sex, ancestry and stature for the sketonized remains of unidentified individuals. The third version of this PC-based program (2005) uses up to 27 cranial, 9 mandibular, and 44 postcranial measurements to sort the test specimen into one of 12 race/sex groups (for crania) or 4 race/sex groups (for postcrania). The on-board database from which the discriminant functions are derived includes nearly 2000 identified individuals, the majority of whom were born after 1930. Most of these come from the Forensic Data Bank, a repository of actual forensic case information sent in by anthropologists from all over North America. Additional specimens are drawn from the Terry Collection at the Smithsonian Institute in Washington DC. Analysts facing particularly difficult cases can compare their specimens to data collected on 54 additional groups from Howells landmark (1973) study of human cranial variation.

An issue that potentially limits the use of FD3 outside of North America is that few non-American populations are well-represented in the main database. The applicability and accuracy of the program has not been verified on worldwide populations. Thus, the purpose of this study is to test the usefulness of FD3 on a sample of known specimens from South Africa.

Materials and Methods

A total of 187 male and female specimens from the Pretoria Bone Collection were used: 86 blacks (BF & BM) and 101 whites (WF & WM) (Table 1). Individuals ranged from 21-97 years old at death. All were free of any visible cranial pathology that might have affected cranial shape, size, or landmark location.

Standard cranial measurements were taken. Specimens had between 18 and 24 measurements available (mode = 23); those with very few measurements are less likely to be correctly classified and therefore could skew the results. The measurements were entered into FD3 and a separate discriminant function was constructed for each specimen, comparing it to the 4 American subgroups that most closely match the origins and ancestral affinities of the South African sample (white males & females, black males & females).

From the results of each discriminant analysis, we recorded the group that the specimen was placed in and the posterior probability of membership in that group. "Posterior probability" (PP) is a percentage that indicates the likelihood of membership in a particular group, with the assumption that the test specimen actually belongs to one of the 4 groups in the function. PP ranges from 0 to 1.0, with higher values indicating greater probability of membership in that group. Therefore, PP can be used as a general indicator of how similar a test specimen is to each of the groups it is compared to in FD3, reflecting the confidence that FD3 has in making the assignment.

Table 1. The study sample. See text for group abbreviations

Group	Number	Percent
BF	31	16.6
BM	55	29.4
WF	44	23.5
WM	57	30.5
Total	**187**	**100.0**

Results

Approximately 73% (137/187) of the South African test specimens were classified correctly by FD3 for ancestry and sex (Table 2). When broken down into ancestry and sex categories, black females performed the worst (48% correct), while white females performed best (82%). For all groups, when FD3 got it wrong, it was most likely to classify the incorrect specimens into the correct ancestral/racial group but into the wrong sex. It seems to have little difficulty distinguishing between blacks and whites or between white males and white females. For estimating ancestry, these results are encouraging, but not so for determining sex.

Table 3 gives the average PP values for each group, which varied between a low of 0.79 for black females and a high of 0.90 for white males. The average PP for the entire sample was 0.87, meaning that FD3 calculated that all specimens were 87% likely on average to belong to their predicted group. Therefore, FD3 classified the South African specimens with fairly high confidence.

Table 2. Classification rates. See text for group abbreviations

Actual Group	Total	FD3 Classification				% Correct
		BF	BM	WF	WM	
BF	31	**15**	**11**	5	0	48
BM	55	**6**	**44**	0	5	80
WF	44	3	1	**36**	**4**	82
WM	57	1	5	**9**	**42**	74

Table 3. Posterior probability values. See text for group abbreviations

Actual Group	Total	Minimum	Maximum	Mean	Std. Deviation
BF	31	0.452	1.000	0.790	0.191
BM	55	0.470	1.000	0.888	0.172
WF	44	0.417	1.000	0.844	0.190
WM	57	0.511	1.000	0.904	0.138

Comparing the means for the same 3 measurements for white males and females (Table 5), we see that South African whites show slightly higher levels of sexual dimorphism than South African blacks (as evidenced by comparing the last columns in Tables 4 & 5). This pattern would tend to make it easier for FD3 to distinguish between the sexes for whites than blacks. However, sexual dimorphism is lower in South Africa for both blacks and whites when compared to the North American sample, and both South African groups are smaller overall when compared to North Americans.

These factors could account for the rather modest success (73% correct overall) of FD3 when applied to the South African test sample. Higher levels of cranial sexual dimorphism in North America make it easier for FD3 to sort specimens by sex. Again, FD3 does not seem to have much trouble distinguishing between whites and blacks in South Africa; most difficulty lies in distinguishing between males and females in both ancestral groups.

Since black females were most likely to be misclassified as black males, it is probable that the pattern or degree of sexual dimorphism in South African blacks differs from that of North American blacks. If South African black males and female crania are more similar to each other in size and shape when compared to the North American black crania in FD3, then the program would have difficulty distinguishing between African blacks. To test this hypothesis, we compared mean values for the 3 most important indicators of sex in the North American black sample: biauricular breadth (AUB), nasal height (NLH), and bizygomatic breadth (ZYB), which together account for more than 62% of the difference between US black males and females.

These variables are automatically given the most weight when FD3 attempts to determine the sex of South African blacks. Table 4 illustrates that the difference between South African black males and females is lower for all 3 measurements when compared to the North American sample, indicating a lower level of sexual dimorphism in South African blacks. This pattern would make it more difficult for FD3 to distinguish between South African black males and females.

Table 4. Sexual dimorphism in the Black Groups. NA = North American (Fd3) data; SA = South African (test) data

Measure-ment	Mean in mm (n)				NA difference	SA difference
	NABF	NABM	SABF	SABM		
AUB	115.6 (53)	121.0 (80)	112.9 (30)	117.5 (55)	5.4	4.6
NLH	47.8 (58)	52.2 (84)	47.1 (31)	49.0 (55)	4.7	1.9
ZYB	122.0 (60)	131.0 (79)	123.5 (30)	130.2 (55)	9.0	6.7

Table 5. Sexual Dimorphism in the White Groups. NA = North American (Fd3) data; SA = South African (test) data.

Measure-ment	Mean in mm (n)				NA difference	SA white difference	SA black difference
	NAWF	NAWM	SAWF	SAWM			
AUB	117.0 (156)	122.9 (258)	117.2 (44)	122.1 (57)	5.9	4.9	4.6
NLH	49.5 (157)	52.9 (260)	49.0 (44)	51.9 (57)	3.4	2.9	1.9
ZYB	120.9 (164)	129.9 (263)	120.8 (44)	128.5 (56)	9.0	7.7	6.7

Discussion/Conclusion

Despite significant cultural, historical, and environmental differences between North American whites and blacks and their South African counterparts, FD3 does a reasonable job sorting the South African test sample. Errors in assignment are not due to the nature of the program or the discriminant techniques used; rather, it is likely that the dataset derived from the University of Tennessee's Forensic DataBank is not entirely representative of South African populations. Specifically, South Africans have slightly smaller crania and display lower levels of sexual dimorphism.

These results are encouraging in that, nearly three quarters of the sample was correctly identified. The question that is important for us to ask is whether 73% is a good enough? Unfortunately, the answer is no, and thus continued use of FORDISC would require that we enter our South African into this database. However, we should not focus solely on skeletal remains from the Pretoria Bone and Raymond A. Dart collections but also from other skeletal collections such as Univerity of Cape Town, Stellenbosch and the University of the Free State, to name a few. In this way, we will be increasing our representative data so that we can make more concrete decisions regarding sex and ancestry in the future.

Acknowledgements

Research Development Programme (RDP): University of Pretoria for funding
Malebo Marebane for her assistance in the Pretoria Bone Collection