Differential Diagnosis of Adult Male Black and White Populations

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The notion of using particular sets of cephalometric measurements (e.g., those comprising the Björk, Downs, Steiner, etc. analyses as described, e.g., by Krogman and Sassouni[1]) to characterize the craniofacial morphology of various ethnic and racial groups, and to pinpoint morphological differences between these groups, has proved to be a valuable tool to the physical anthropologist and orthodontist alike. A number of investigations of this type were prompted by Björk's[2,3] classical study of prognathism in Swedish conscripts and North African Bantu males in which Björk attempted to isolate the influences of racial variation, individual variation, ontogenetic change, domestication and racial admixture on the degree of prognathism. Cotton, Takano and Wong[4] used the Downs variables in a comparative study of American Blacks, Nisei and American Chinese. The authors emphasized that, although the mean values of certain of the measurements differed considerably from each other and from the norms for American Whites, there was substantial overlap in the ranges of measurement for these ethnic groups. Haralabakis[5] also used the Downs analysis in his investigation of morphologic similarities within Greek families. Kayukawa[6] combined the Björk and Downs analyses in a study of adolescent Japanese; Craven[7] used a similar set of measurements to characterize the dentofacial form of the Central Australian Aboriginal. Other Australian tribes were studied by Brown[8] and Barrett, *et al.*[9] Lysell and Filipsson[10] used the Björk analysis on a series of medieval skulls from North Sweden and Hong[11] compared several analyses in the study of sexual dimorphism among Formosan Chinese.

In this paper we characterize the American adult male Black and White populations in terms of the descriptive statistics for the Steiner[12,13,14] variables and use the statistical technique of discriminant function analysis[15,16] to study the observed morphological differences in mean values in the context of within-group and between-group variability.[17] It is shown that significant differences between these groups exist and argued that these findings require the differential diagnosis of orthodontic treatment requirements for the two populations.

METHODS AND MATERIALS

The present investigation is based on cephalometric data obtained from the Veterans Administration Hospital in Ann Arbor, Michigan. Two groups of individuals are involved: The first group consists of 244 Black adult males ranging in age from twenty to sixty years; the second consists of 381 White males in the same age range. Both groups were seen for care at the V.A. Hospital, but were selected to be otherwise representative of the American adult male population, i.e., only patients with "normal" medical histories were included in the study.

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TABLE I

Normative values for the variables included in the Steiner cephalometric analysis

Variable	*Norm*
SNA	82°
SNB	80°
ANB	2°
GoGn/SN	32°
Occl./SN	14.5°
$\underline{1}/\overline{1}$	130°
$\underline{1}$ to NA	4 mm.
$\underline{1}$/NA	22°
$\overline{1}$ to NB	4 mm.
$\overline{1}$/NB	25°
$\overline{1}$/GoGn	93°
$\underline{6}$ to NA	27 mm.
$\overline{6}$ to NB	23 mm.

The cephalometric data were processed as previously described by Walker and Kowalski[14,18] and the values of the thirteen Steiner variables were extracted from our model of craniofacial morphology for statistical analysis. Nine angular and four linear variables comprise the Steiner battery and these, along with the normative or "ideal" values for these variables as proposed by Steiner, are given in Table I. All statistical analyses were performed using MIDAS (Michigan Interactive Data Analysis System) developed at the Statistical Research Laboratory of the University of Michigan.

Results

Table II gives the descriptive statistics (sample size, mean, standard deviation, and standard error of the mean) for the Steiner variables for the Black and White samples, respectively. The sample sizes may vary within a group due to the presence of missing data for certain of the variables. The standard error of the mean may be conveniently used to obtain *confidence intervals* for the population mean value within the groups. For example, given the size of our samples, the 95% confidence interval for any given variable is approximately mean ± 2xS.E. of mean so that, in the Black population, the 95% confidence interval for the mean SNA angle is (85.54, 86.66).

A cursory, visual inspection of this table is perhaps sufficient to indicate that the Black and White samples differ considerably from each other and from the normative or "ideal" values for these measurements. A more rigorous approach to the study of these differences is, however, available through the use of the statistical technique of discriminant function analysis as previous-

TABLE II

Descriptive statistics for the Steiner variables

	Black				*White*			
Variable	*N*	*Mean*	*S.D.*	*S.E. of Mean*	*N*	*Mean*	*S.D.*	*SE of Mean*
SNA	244	86.10	4.43	.28	381	82.18	3.78	.19
SNB	244	81.22	4.00	.26	381	78.94	3.69	.19
ANB	244	4.88	2.64	.17	381	3.23	2.46	.13
GoGn/SN	244	34.31	6.44	.41	381	32.89	6.61	.34
Occl./SN	199	15.48	5.99	.42	298	15.09	5.70	.33
$\underline{1}/\overline{1}$	235	126.31	12.19	.79	360	136.47	11.12	.57
$\underline{1}$ to NA	235	4.83	3.08	.20	367	3.69	2.55	.13
$\underline{1}$/NA	235	32.20	8.73	.57	367	32.95	8.01	.42
$\overline{1}$ to NB	242	9.15	3.57	.23	374	4.62	2.76	.14
$\overline{1}$/NB	242	30.14	7.36	.47	374	20.56	7.02	.36
$\overline{1}$/GoGn	242	94.59	7.41	.48	374	88.67	7.72	.40
$\underline{6}$ to NA	207	26.77	4.50	.31	307	25.02	3.46	.20
$\overline{6}$ to NB	183	18.97	4.99	.37	290	19.86	3.69	.22

TABLE III

The classification matrix for a linear discriminant analysis based on all of the Steiner variables

	Black	*White*	*Total*
Black	128	37	165
White	36	213	249

TABLE IV

The classification matrix for a stepwise linear discriminant analysis based on just seven of the Steiner variables

	Black	*White*	*Total*
Black	125	40	165
White	38	211	249

ly described in a similar context by Harris, Kowalski and Walker[15] and, in a slightly different vein, by Harris, Nasjleti and Kowalski.[16] The results of the *linear* discriminant function analysis may be conveniently summarized by the classification matrix given in Table III. It is seen that of the total of 165 Blacks available for classification (MIDAS processes only those individuals for whom there are no missing data), 128 or 77.6% were correctly classified as Black on the basis of the values of the Steiner variables while 37 or 22.4% were incorrectly classified as White. Of the 249 Whites, 213 (85.5%) were correctly classified; 36 (14.5%) misclassified.

When the discriminant function analysis was performed in a *stepwise* manner,[15,16] including only those variables significant at the 5% level of significance, seven variables were included. These, in decreasing order of discriminatory power, are: $\bar{1}$ to NB, SNA Occl./SN, $\bar{6}$ to NB, ANB, $1/\bar{1}$ and 1 to NA. This means that the best *single* discriminator is 1 to NB. Given that this measurement is included in the discriminant functions, the variable adding the most additional (nonredundant) classificatory information is SNA, and so on. The variables not listed are redundant in the sense that they provide no *new* information (by virtue of the correlation among the variables) to that already contained in the selected variables and may therefore be omitted from the analysis. When this is done, the classification matrix is as shown in Table IV. It is seen that no appreciable loss in discriminatory power occurs when only this subset of the Steiner variables is used.

Further examination of these data indicated, however, that one of the assumptions upon which the use of the *linear* discriminant function analysis is based, namely, that of equality of variances and covariances (or correlations) in the two groups, was not satisfied. In this situation, although very little use of this strategy is evident in the literature, Kowalski[17] has argued that *quadratic* discriminant function analysis[19] be employed. When this is done, the resulting classification matrix is as shown in Table V, and it is seen that over 84% of the individuals are correctly classified.

Discussion

It seems clear, whether this observation be framed in terms of the observed mean values in the two groups or in the context of the results of the discriminant function analyses, that there are substantial Black/White differences in dentofacial morphology as reflected by the values of the Steiner variables. While some overlap in the ranges of measurement for all of the variables exists, as first pointed out by Cotton, Takano and Wong,[4] discriminant function analysis may be used to produce (linear or quadratic) functions of these variables having minimal overlap (this

TABLE V

The classification matrix for a quadratic discriminant analysis based on the Steiner variables

	Black	*White*	*Total*
Black	140	25	165
White	40	209	249

overlap being measured by the proportions of misclassification) which may be used to correctly classify the great majority of individuals.

The single most effective discriminator in the Steiner analysis was found to be the $\overline{1}$ to NB distance as measured in the context of Walker's[14,15] two-dimensional coordinate model of craniofacial morphology. Inspection of the distributions of this variable in the two populations leaves little doubt that the proclination of the lower incisor to the line NB is much higher in Blacks, as is the degree of maxillary prognathism, as measured by the SNA angle. The cant of the occlusal plane relative to the cranial base is also a bit more severe. The interincisal angle is considerably higher in the White sample.[14]

These differences, while perhaps of some interest in-and-of-themselves, suggest that different orthodontic norms, or "ideal" values, may be necessary if we are to adequately treat both races, fully cognizant of such morphological differences as have been shown to exist. While the individuals included in the present study are clearly outside the range of ages of the typical orthodontic patient, there is some evidence that craniofacial *shape* remains fairly stable with increasing age,[20] though some caution must be exercised in this regard, especially for male mandibular morphology.[21]

The need for these adjustments to the values given in Table I was, of course, recognized by Steiner[13] who cautioned: "Please bear in mind that these are rough estimates, to be used as a starting point from which to vary and must be modified by other factors . . . age, sex, race, growth potential and individual variations within these and other groupings." The results of this paper support the need for modification of these norms according to race and show which of the Steiner variables are most sensitive to racial variation.

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