Secular Trends in Different Racial Groups

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Introduction

The existence of a secular trend in stature is a well-documented phenomenon.[1-11] Thus the stature of offsprings tends to exceed that of their parents in different racial groups, although it has been suggested that such a trend may now be ending in some privileged population samples.[12,13] Similar secular trends have also been reported for the face,[14] dental arch[15] and teeth.[16] But although secular trends have been recorded for different racial groups for stature, inquiries into other bodily or dental dimensions have been either restricted to Caucasoids only or based upon nonrelated subjects.

The present investigation was undertaken to examine the secular trends for stature, skeletal, dental arch and tooth size in three racial groups: Caucasoids, Negroids and Mongoloids. Such an investigation has far reaching consequences, since, in multiracial societies, it is important to ascertain whether each racial group must be regarded separately, or the population considered as a whole.

Materials and Methods

This investigation was based upon comparisons between male and female parents each with male and female offspring, i.e., each family comprised father, mother, son and daughter. A total of sixty families were included, containing 240 individuals derived from equal samples of Caucasoids, Negroids and Mongoloids. The Caucasoid sample was derived from West Midlands British subjects residing within a twenty mile radius of Birmingham. Both Negroid and Mongoloid samples, in contrast, were based upon immigrants from Hong-Kong and Africa who had resided in the United Kingdom for not more than ten years.

Whereas ideally, it would have been better to measure offspring who had fully completed their growth changes, in practice, the parents of such offspring had a considerable number of missing teeth. Consequently, in order to obtain comparable parent samples, the offspring were aged fourteen years or older. Nevertheless, in view of the observations of Tanner,[17] most of the offspring were assumed to have completed most of their major growth changes.

Although all the families included in this investigation comprised two siblings, it was not possible to select only those where sons were older than daughters, or vice versa. Nevertheless, in each population sample approximately fifty per cent of the families had sons older than daughters.

The families included in this investigation were selected on the basis that each had (a) complete permanent dentitions (excluding the third permanent molars), (b) no obvious skeletal, facial or dental abnormality, and (c) all individuals had approximately the same somatotype.[18]

Using standard anthropological techniques,[19] the following dimensions were measured on each subject:

1. Stature,
2. Skeletal dimensions: a) lengths of humerus, radius and tibia, b) widths of knee, wrist and elbow,
3. Skull dimensions: a) head length, width and circumference, b) biauricular, bicondylar, bizygomatic and bigonial widths,
4. Dental arch dimensions from

TABLE 1. MEAN PERCENTAGE DIFFERENCE BETWEEN DIMENSIONS OF PARENTS AND OFFSPRING

DIMENSIONS	CAUCASOID			MONGOLOID			NEGROID		
	Father/ Son	Mother/ Daughter	Son/ Daughter	Father/ Son	Mother/ Daughter	Son/ Daughter	Father/ Son	Mother/ Daughter	Son/ Daughter
Stature	5.24	0.30	9.10	0.56	0.57	2.01	1.13	0.06	3.18
Overall skeletal dimensions	4.01	2.00	7.42	2.66	4.76	5.96	4.84	4.36	4.51
Overall skull dimensions	4.69	3.25	7.17	3.37	3.51	5.66	7.15	3.16	5.74
Maxillary arch dimensions	1.89	0.67	5.40	2.27	2.53	3.02	2.66	1.68	5.22
Mandibular " "	1.52	-0.41	3.46	1.51	0.71	3.07	1.62	1.39	3.02
Maxillary tooth dimensions	2.19	1.99	2.77	3.52	1.72	3.04	2.91	0.63	5.61
Mandibular " "	2.58	2.04	2.73	-1.28	1.61	1.31	1.91	-0.38	5.94

casts: a) width, distance between the centres of corresponding teeth on each side of the dental arch. The arch widths between the first molars, canines and central incisors were measured, b) length, minimum distance between the most mesial aspect of anterior teeth to the most distal aspect of posterior teeth. The lengths, measured on the left side of the dental arch, were between the central incisors and canines, and between the central incisors and first molars.

5. Tooth dimensions: mesiodistal and buccolingual crown diameter. These tooth dimensions were measured for the incisors, canines, premolars, and first and second molars on the left side of the maxillary and mandibular dental arches. In a few cases the dimensions of isolated teeth on the right rather than left side of the dental arch were measured due to loss of tooth substance arising from fillings or attrition.

As a check on accuracy, all the above dimensions were measured five times by two independent observers on ten subjects selected at random. Any inconsistencies arising from the measurement technique proved statistically insignificant ($P > 0.2$), when compared with the variation existing between different individuals by analysis of variance.

The data for each individual were checked to determine their validity and homogeneity. Thus, from computer print-outs of plots of means against standard deviations on both arithmetic and logarithmic scales, any "rogue" measurements were immediately apparent. They were then rechecked in order to determine whether or not they were due to errors in measurement.

Results

The mean dimensions for parents and offspring were compared between the various racial groups, as summarized in Table 1. In Caucasoids, Mongoloids and Negroids there was an overall average increase in dimensions of sons over fathers by 3.1, 1.8 and 3.2%, respectively. Similarly, the various dimensions relating to daughters were greater than those for mothers, the overall average increase being 1.4% for Caucasoids, 2.2% for Mongoloids and 1.6% for Negroids. These differences proved statistically insignificant ($P > 0.2$) for each racial group. There were, however, certain exceptions to this overall trend. In Caucasoids, for instance, the average mandibular arch dimensions were 0.4% greater for mothers than daughters. In addition, the average mandibular tooth dimensions were 1.3 % greater in fathers than sons for Mongoloids, whereas in Negroids, these average dimensions for mothers exceeded those for daughters by 0.4%.

The data also showed that, in all the dimensions measured, those for sons were greater than those for daughters. The overall average degree of sexual dimorphism between sons and daughters was 5.4% for Caucasoids, 3.4% for Mongoloids and 4.7% for Negroids. The degree of sexual dimorphism between parents, in contrast, tended to be less, i.e., 3.8% for Caucasoids, 4.2% for Mongoloids and 2.9% for Negroids. This degree of sexual dimorphism between parents did not differ significantly ($P > 0.2$) compared with that between offspring.

From the correlation coefficients listed in Table 2, it is apparent that there was no consistent indication for stature, skeletal, skull or dental arch dimensions of parents being significantly correlated with those of their offspring. Similarly, no significant correlations were determined between the various dimensions of sons and daughters. Furthermore, the data provided no indication that there was a greater degree of correlation between the dimensions relating to one racial group compared with another. A similar conclusion may be derived from the correlation coefficients relating to the tooth dimensions, listed in Table 3, which also pointed to no apparent racial differences.

Thus, the general conclusions derived from these data are that the dimensions for parents bear little relationship to those of their offspring, and the dimensions of offspring bear little relationship one with another.

It is evident, however, that the univariate statistical techniques, used hitherto, enabled only one or two dimensions to be considered at any one time. In order to obtain an overall picture, therefore, all the dimensions for each individual were combined, and subjected to a canonical analysis of discriminance. This is a multivariate technique, which not only enabled all the dimensions to be combined whilst eliminating any correlation between them, but also served to maximise the separation mathematically between the constituent groups. Thus from the generalized distance ($\sqrt{D^2}$) matrix, a measure of the separation between the centroids for parents and offspring, it was possible to determine whether the overall dimensions combined for parents and offspring differed in the three racial groups.

Canonical analyses were performed on the following data for each racial group: all the dimensions combined (see Table 4), all the skeletal dimensions combined, all the skull dimensions combined, all the arch dimensions combined, and all the tooth dimensions combined. Similar patterns of contrast were evident from each of the canonical analyses which confirmed that there was little racial difference in the degree of separation between either parents or offspring.

Discussion

The subjects included in this investigation were selected from those attending for routine dental treatment or advice. Thus, the population samples were not homogeneous and were derived from a variety of socioeconomic groups. This may have masked some of the secular trends, since although Craig[9] noted such trends for stature in both rich and poor individuals, Bakwin and McLaughlin[12] noted no such trend in "privileged" communities. Damon,[13] in contrast, has reported that whereas secular increases in height have ended amongst economically favoured Americans, weight may still be increasing.

The present data showed a secular trend for an increase in stature, skeletal, skull, dental arch and tooth dimensions, although there was no indication that this trend was more marked for some

TABLE 2. CORRELATIONS BETWEEN STATURE, BODILY AND SKULL DIMENSIONS OF PARENTS AND OFFSPRING

	CAUCASOID					MONGOLOID					NEGROID				
	Father/ Son	Mother/ Daughter	Father/ Daughter	Mother/ Son	Son/ Daughter	Father/ Son	Mother/ Daughter	Father/ Daughter	Mother/ Son	Son/ Daughter	Father/ Son	Mother/ Daughter	Father/ Daughter	Mother/ Son	Son/ Daughter
Stature	-0.46	-0.14	-0.35	-0.29	-0.35	0.45	-0.12	-0.37	-0.38	-0.17	-0.39	-0.19	-0.49*	-0.21	-0.42
Body:-															
Humerus length	-0.43	-0.10	-0.21	-0.13	-0.26	-0.54*	-0.11	-0.28	-0.29	0.26	-0.37	-0.21	0.53*	-0.42	0.38
Radius length	-0.31	-0.32	-0.43	-0.08	0.19	-0.37	-0.40	-0.34	0.18	-0.30	-0.43	-0.27	-0.28	0.05	-0.29
Tibial length	-0.46	0.17	0.12	0.37	0.08	-0.48*	0.11	0.08	-0.29	-0.28	-0.39	0.25	-0.31	0.17	-0.15
Knee width	0.33	-0.51*	0.08	0.15	-0.13	0.52*	-0.46	0.17	-0.36	0.39	0.48*	-0.65*	0.14	-0.19	0.29
Wrist width	0.39	-0.25	-0.17	-0.49*	-0.27	0.36	-0.22	-0.29	-0.14	0.42	0.42	-0.29	-0.29	0.28	0.07
Elbow width	0.19	-0.60*	0.39	0.14	0.16	0.28	-0.56*	0.31	0.29	0.18	0.29	-0.66*	0.36	-0.30	-0.17
Skull:-															
Head length	-0.09	0.43	-0.46	-0.58*	0.28	-0.07	0.45	-0.28	0.08	-0.11	-0.07	0.52*	0.15	-0.26	-0.19
Head width	0.40	0.39	0.59*	0.63*	0.46	0.25	0.46	0.36	-0.14	0.07	0.29	0.40	-0.19	0.35	0.28
Head Circumference	-0.35	-0.16	-0.17	-0.12	-0.11	-0.13	-0.20	0.14	-0.11	-0.09	-0.28	-0.19	0.35	-0.19	0.30
Biauricular width	-0.10	0.04	0.19	0.07	0.10	-0.24	0.02	-0.28	0.06	0.20	-0.17	0.09	0.47	-0.22	-0.17
Bicondylar width	-0.21	-0.25	0.27	0.14	0.25	-0.29	-0.36	-0.39	0.17	0.24	-0.29	-0.35	-0.28	0.09	0.46
Bizygomatic width	0.34	-0.12	0.15	-0.09	-0.19	0.38	-0.11	0.42	-0.19	-0.29	0.46	-0.21	-0.36	-0.14	0.48*
Bigonial width	-0.37	0.04	0.28	0.26	0.19	-0.46	0.08	0.11	0.26	0.18	-0.52*	0.06	0.19	0.19	-0.37
CORRELATIONS BETWEEN DENTAL ARCH DIMENSIONS OF PARENTS AND OFFSPRING															
Maxilla 6-6	-0.03	0.63*	-0.06	-0.28	-0.13	0.02	0.59*	-0.06	-0.35	-0.31	0.15	0.67*	-0.06	0.07	-0.42
3-3	0.41	0.14	0.39	-0.37	0.27	0.56*	0.18	-0.17	-0.21	-0.17	0.46	0.29	0.14	0.39	-0.36
1-1	-0.06	0.08	-0.14	0.14	-0.13	-0.08	0.06	0.27	0.18	0.28	-0.22	0.14	-0.39	-0.28	0.38
1-6	0.32	0.08	-0.63*	0.29	0.35	0.39	0.04	0.30	0.07	0.30	0.41	0.09	0.14	-0.19	0.27
1-3	0.44	-0.22	0.15	-0.52*	0.39	0.49	-0.29	0.11	0.11	0.16	0.54*	-0.36	0.35	-0.56*	-0.19
Mandible 6-6	-0.09	-0.12	-0.20	-0.16	-0.42	-0.14	-0.20	-0.59*	-0.19	-0.41	-0.12	-0.22	-0.29	-0.56*	-0.25
3-3	-0.06	0.40	-0.14	0.19	0.28	-0.09	0.46	0.37	0.27	-0.12	-0.15	0.48*	0.18	0.27	0.38
1-1	-0.69	-0.18	-0.36	0.28	-0.31	-0.45	-0.19	0.17	-0.06	0.18	-0.59*	-0.27	-0.31	0.11	0.29
1-6	-0.04	0.60*	0.11	-0.31	0.35	-0.29	0.58*	-0.29	-0.37	0.29	-0.18	0.41	-0.46	-0.18	-0.44
1-3	0.16	0.16	0.06	0.42	0.21	0.18	0.27	-0.46	0.38	-0.06	0.27	0.38	0.49*	0.36	-0.26

* = Statistically significant correlation co-efficient ($P < 0.02$)

TABLE 3. CORRELATIONS BETWEEN TOOTH DIMENSIONS OF PARENTS AND OFFSPRING

		CAUCASOID					MONGOLOID					NEGROID				
		Father/ Son	Mother/ Daughter	Father/ Daughter	Mother/ Son	Son/ Daughter	Father/ Son	Mother/ Daughter	Father/ Daughter	Mother/ Son	Son/ Daughter	Father/ Son	Mother/ Daughter	Father/ Daughter	Mother/ Son	Son/ Daughter
Maxillary:-																
1st Incisor	MD	0.14	0.28	-0.28	-0.44	-0.35	0.25	-0.09	-0.45	0.11	-0.52*	-0.49*	0.33	-0.38	-0.29	-0.38
	BL	0.34	-0.22	0.36	-0.51*	0.19	0.45	-0.37	-0.28	-0.18	-0.51*	0.70*	-0.44	0.39	0.30	-0.56*
2nd Incisor	MD	0.73*	0.68*	0.42	0.18	-0.28	0.20	0.28	0.31	0.37	0.47*	-0.03	-0.39	-0.47	-0.28	-0.49*
	BL	-0.12	-0.23	-0.28	0.29	-0.52*	0.26	-0.03	0.11	0.19	0.72*	-0.18	-0.32	0.11	-0.41	0.58*
Canine	MD	0.56*	0.66*	-0.17	-0.56*	0.59*	0.39	-0.37	0.18	0.20	-0.60*	0.16	-0.06	0.18	0.45	0.59*
	BL	0.10	-0.39	0.19	0.67*	0.65*	-0.38	-0.14	0.32	0.17	0.60*	-0.37	-0.26	0.29	0.52*	0.47
1st Premolar	MD	-0.60*	0.02	0.28	-0.19	0.28	0.19	-0.05	0.36	0.19	0.47	-0.13	0.46	0.30	-0.50*	0.38
	BL	0.10	0.46	0.35	0.28	-0.36	-0.06	0.57*	-0.17	0.35	0.49*	-0.41	-0.08	-0.36	0.47	0.37
2nd Premolar	MD	-0.06	0.16	-0.07	-0.35	-0.47	0.18	0.27	-0.19	-0.39	0.72*	0.17	0.01	0.44	0.54*	0.42
	BL	-0.23	-0.39	-0.19	-0.28	0.72*	-0.18	-0.20	0.28	-0.47	-0.73*	0.14	0.03	0.47	-0.59*	-0.49*
1st Molar	MD	-0.24	-0.28	-0.23	0.39	0.76*	0.03	-0.12	0.14	0.48*	-0.43	-0.44	0.57*	-0.38	-0.50*	-0.38
	BL	-0.44	0.33	0.35	-0.44	0.18	-0.03	-0.03	0.19	0.45	0.44	0.02	-0.14	-0.36	0.39	-0.37
2nd Molar	MD	-0.45	0.73*	0.59*	0.18	-0.19	0.37	0.18	-0.08	-0.28	0.50*	0.02	0.38	0.39	0.48*	0.42
	BL	0.40	-0.02	0.60*	0.28	0.35	0.20	-0.46	0.36	0.36	0.50*	0.06	-0.46	0.32	0.49*	0.55*
Mandibular:-																
1st Incisor	MD	0.40	-0.11	-0.48	0.35	-0.39	0.26	-0.33	0.11	0.77	0.49*	-0.02	-0.35	0.35	-0.48*	-0.63*
	BL	0.22	0.01	-0.36	0.18	0.47	-0.08	-0.32	0.17	0.14	-0.53*	-0.06	0.26	0.41	0.36	0.68*
2nd Incisor	MD	0.41	-0.06	0.11	-0.20	-0.18	-0.01	-0.09	-0.19	0.19	-0.54*	0.20	0.82*	-0.42	0.38	0.47
	BL	-0.44	-0.09	0.18	0.19	-0.52*	0.23	-0.28	-0.27	0.28	-0.47	0.14	-0.28	0.35	-0.27	-0.49*
Canine	MD	-0.16	-0.48*	0.29	0.28	0.59*	0.02	0.29	0.18	-0.44	0.49*	-0.17	-0.10	-0.39	-0.29	-0.52*
	BL	-0.29	0.13	0.42	-0.35	0.60*	0.05	-0.31	0.35	-0.46*	0.54*	0.16	-0.27	0.40	0.48*	0.32
1st Premolar	MD	-0.37	-0.08	0.45	0.29	0.47	0.29	0.36	-0.37	0.52*	0.48	0.30	-0.20	-0.40	0.39	0.36
	BL	-0.38	-0.46	0.39	0.36	0.71*	0.26	-0.34	0.28	0.59*	0.49*	0.39	-0.15	-0.38	0.52*	0.51*
2nd Premolar	MD	0.03	-0.14	0.48	-0.35	-0.83*	-0.12	0.06	-0.34	-0.18	0.55*	-0.28	0.41	0.36	-0.46	-0.48
	BL	-0.16	0.40	-0.37	-0.11	0.67*	-0.17	0.28	-0.38	0.19	0.59*	-0.35	-0.04	-0.28	0.35	0.30
1st Molar	MD	-0.01	0.33	-0.34	0.19	0.43	0.08	-0.30	0.17	0.28	-0.60*	-0.23	-0.14	0.37	0.38	-0.30
	BL	0.23	0.13	-0.20	0.25	0.44	-0.02	0.06	0.19	0.36	0.60*	-0.15	-0.49*	0.39	-0.47	-0.47
2nd Molar	MD	-0.05	-0.29	0.19	-0.18	-0.41	0.11	0.09	0.26	-0.34	0.47	0.09	-0.32	0.26	-0.49*	-0.49*
	BL	0.25	0.12	-0.28	0.34	0.38	0.16	-0.36	-0.14	-0.41	-0.49*	0.10	-0.26	0.27	-0.50	0.27

BL = Buccolingual diameter

MD = Mesiodistal diameter

* Statistically significant correlation co-efficient ($P<0.02$)

TABLE 4
SQUARED GENERALISED DISTANCES ($\sqrt{D^2}$) BETWEEN THE CENTROIDS OF THE VARIOUS RACIAL GROUPS BASED UPON CANONICAL ANALYSIS OF ALL THE BODILY, SKULL, ARCH AND TOOTH DIMENSIONS COMBINED TOGETHER

	Father/ Son	Mother/ Daughter	Father/ Mother	Son/ Daughter	Father/ Daughter	Mother/ Son
Caucasoids	6.61	7.03	8.09	8.15	7.45	11.52
Mongoloids	8.41	6.31	8.30	9.21	8.23	12.55
Negroids	7.27	6.93	13.70	14.72	11.18	16.99

Distances in standard deviation units.

dimensions compared with others. Thus, despite age differences, the present data showed that the dimensions of sons were greater than those for fathers, and those for daughters were greater than those for mothers.

This secular trend was apparent in Caucasoids, Mongoloids and Negroids, there being no marked racial or sex differences. Whereas these conclusions confirmed those of Kimura[20] relating to height and weight in different population samples, they were not in agreement with those of Acheson and Fowler[10] who noted a more marked secular increase in the dimensions of males than females.

It has previously been shown that stature is poorly correlated with skull, dental arch and tooth dimensions in adults of the three groups. In contrast, tooth and dental arch dimensions were found to be highly correlated one with another, especially in Mongoloid and Negroid population samples.[21] Hence, whereas within the same individual, arch and tooth dimensions appear to be correlated one with another, such a definite relationship does not appear to exist between parents and offspring.

The general low degrees of correlation between the dimensions of parents and offspring are suggestive that environmental rather than genetic factors play a major role in determining the dimensions of the stature, skeletal, skull, dental arch and teeth. This tends to support previous findings relating to the arch[15] and teeth.[22] Furthermore, the results also appear to confirm the experimental evidence that nutrition affects tooth dimensions,[23,24] and muscle action affects jaw size and shape.[25]

Thus it is apparent that, whereas little indication of the dimensions of the offspring may be obtained from the parents, the existence of a secular increase in dimensions of the skull, dental arch and teeth must be taken into account in the treatment of the three racial groups.

Summary and Conclusion

Stature, skeletal, skull, dental arch and tooth dimensions were measured in sixty families, comprising equal samples of Caucasoids, Mongoloids, and Negroids. A secular increase in all these dimensions was noted between parents and offspring, there being no apparent difference between the three racial groups. In addition, a low degree of correlation was noted between the dimensions of parents and offspring.

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