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A MULTIVARIATE APPROACH TO THE MORPHOLOGY OF A POPULATION OF CHILDREN IN GENEVA AGED FROM 4 TO 19½ YEARS

by M. Bakonyi and P. Moeschler

(Department of Anthropology, University of Geneva, Geneva, Switzerland)

A b s t r a c t. A factor analysis by principal components was conducted on anthropometric variables from a sample of 5578 children and adolescents aged 4 to 19.5 years, living in Geneva, Switzerland. The variables used in this analysis are biacromial diameter, sitting height, weight, upper arm length, total arm length, arm cirumference, bicristal diameter, bizygomatic breadth, leg length, face height, antero-posterior diameter, transverse diameter, subscapular skinfold, triceps skinfold. Mean values by sex were calculated at half-year intervals. The main results obtained are as follows.

The first factor is a general growth factor, the second and third factors account for the evolution of morphology through time. This is particularly clear when these latter two factors are related to the first. The second factor is bipolar, opposing weight and breadth measurements to head and length measurements. The skinfolds play an important role in this factor, particularly the triceps skinfold. The third factor is more complex and can be characterized by the importance of the weighting attributed to the subscapular skinfold.

Briefly, a principal components analysis reveals the part played by skinfolds during growth and brings out the evolution of the morphological type. A discussion of this last point is developed in this paper.

Key words: growth and development, Geneva children, factor analysis by principal components.

Introduction

Certain methods frequently used in multivariate analysis have the advantage that they give an idea of the possible structures of a set of data in the absence of any hypothesis. This is what incited us to use the analysis by principal components for the study of growth of the children of Geneva. Even though the very nature of our data leads to an analysis of a particular correlation matrix (the coefficients all have very high values) with the consequence that the first factor in itself explains 88% of total variance, it seemed interesting to present here what the results of our calculations could suggest.

Material and Methods

This study concerns a sample, representative of the Swiss population of Geneva, constituted of 5578 children and adolescents (2860 boys and 2710 girls) aged from 4 to 19½ years, measured in 1972 and divided into six month's age-groups. For each of the 62 age groups thus obtained we have calculated

the mean values of the 14 measurements appearing in Table 1. These sixty-two groups each characterized by 14 mean values, constitute the total data (sexes and age-groups combined) on which a factor analysis by principal components has been carried out. The results of this analysis are examined here factor by factor.

Results

Factor one (Table 1)

The first factor is a general growth factor which gives the age groups according to the ascending order of their mean values.

Table 1—Factor 1

Biacromial	0.2831
Sitting height	0.2831
Weight	0.2823
Upper arm length	0.2823
Total arm length	0.2817
Arm circumference	0.2806
Bi-iliocristal	0.2803
Bizygomatic	0.2797
Leg length	0.2795
Face height	0.2770
Antero-posterior diameter of the head	0.2580
Transverse diameter of the head	0.2548
Scapular fold	0.2284
Triceps fold	0.1643

Therefore it is not surprising at all that these mean values appear along the axis on which they figure (Figure 1) in the ascending order of the subject's average age-groups, taking into account sexual variation.

Factor two (Table 2)

The second factor is bipolar, opposing skinfolds to the head measurements. This allows us to separate the sexes in an almost perfect manner (with one exception: boys of 4 to 4½), the value of the function is at all tissues, lower for the boys than for the girls, and this no matter what age group is compared (Fig. 1).

Table 2—Factor 2

Triceps fold	0.6911
Scapular fold	0.4698
Bi-iliocristal	0.1123
Arm circumference	0.0795
Weight	0.0223
Sitting height	0.0208
Upper arm length	0.0098
Leg length	−0.0189
Biacromial	−0.0331
Total Arm Length	−0.0523
Bizygomatic	−0.1190
Face height	−0.1629
Antero-posterior diameter of the head	−0.3321
Transverse diameter of the head	−0.3557

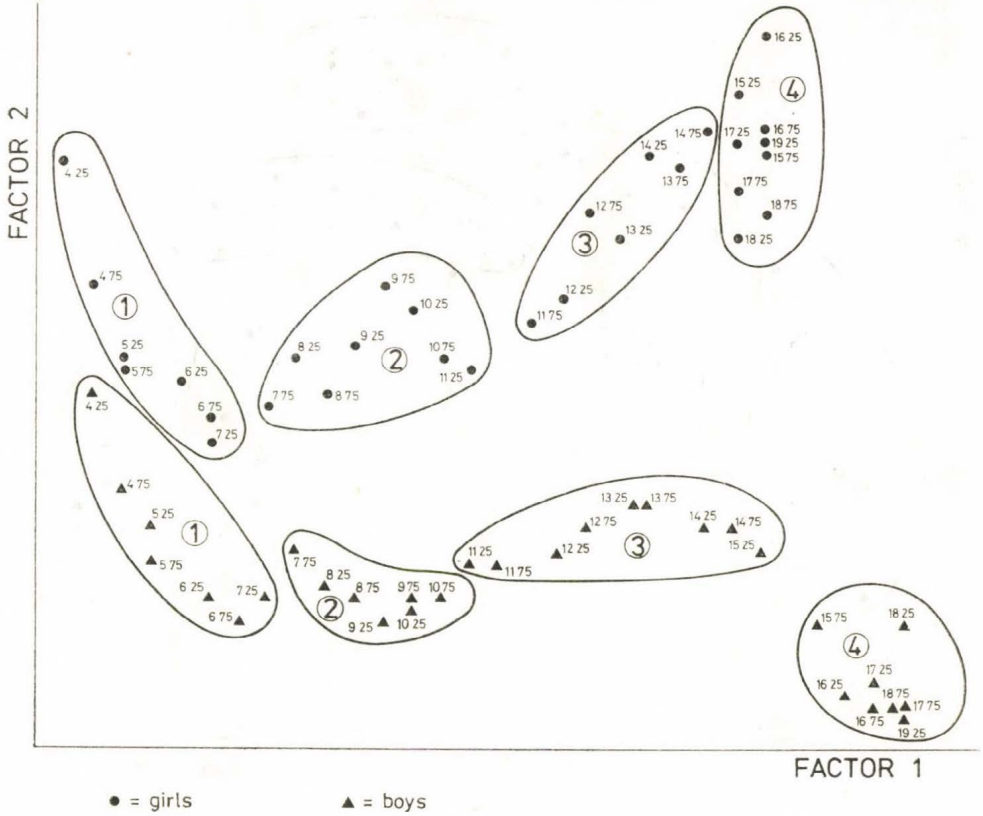

Fig. 1: Factor 1 and factor 2. Age-group distribution (see text). ● = girls, △ = boys

Factor three (Table 3)

Table 3—Factor 3

Leg length	0.4495
Total arm length	0.2744
Upper arm length	0.2582
Triceps fold	0.2185
Face height	0.1051
Sitting height	0.0694
Biacromial	0.0561
Bi-iliocristal	—0.0121
Bizygomatic	—0.0853
Arm circumference	—0.1007
Weight	—0.1167
Transverse diameter of the head	—0.2675
Antero-posterior diameter of the head	—0.2904
Scapular fold	—0.6341

The third factor differentiates the length measurements and the triceps fold from the scapular fold, head measurements and, in a more general manner, from the volume indicators (weight, perimeters and transverse diameters).

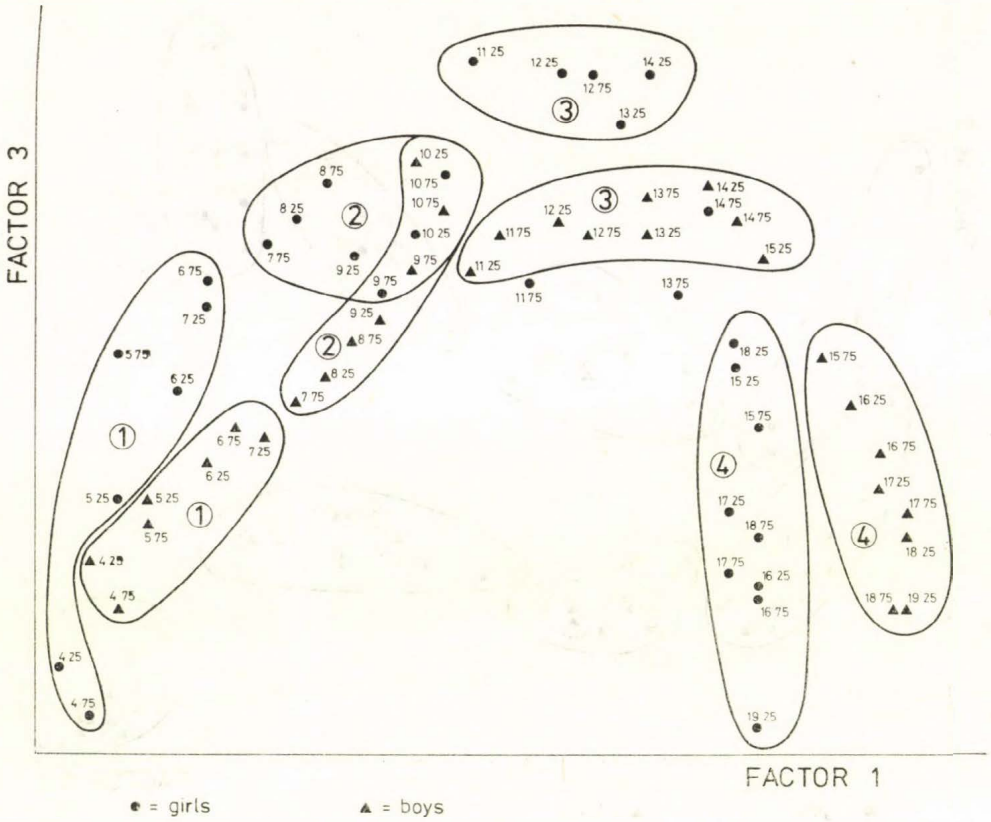

Fig. 2: Factor 1 and factor 3. Age-group distribution (see text). ● = girls, △ = boys

The values of the function are approximately the same for the oldest and the youngest boys and girls (Fig. 2). These values are at all tissues higher for the boys, as they are for the girls at or around the age of puberty.

Typological analysis

The global comprehension of the combination two by two of the factors 1, 2 and 3 (Figures 1, 2 and 3) suggests for each sex the existence of four different morphological types relative to the 14 variable involved. They are in Figure 3. The first regroups the age groups comprised between 4 to 7½ years, the second those between 7½ to 11 years, the third those between 11 to 15½ years for the boys and 11 to 15 years for the girls. Lastly, a forth group includes for both sexes the oldest individuals. We want to point out that age limits between groups are almost the same for both sexes.

The same analysis by principal components carried out for each sex separately permits us to verify the existence of the four mentioned groups.

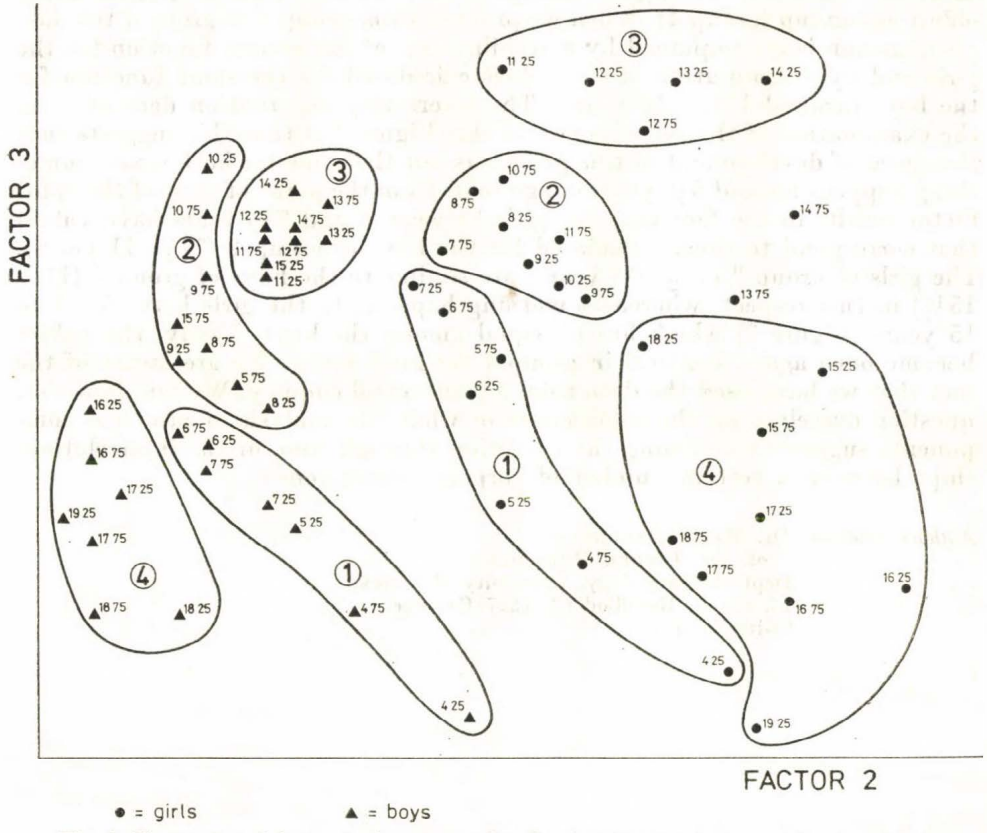

Fig. 3: Factor 2 and factor 3. Age-group distribution (see text). ● = girls, △ = boys

A tentative interpretation (Figure 3)

We limit ourselves here to what the structure of the set of points in Figure 3 suggests. The biological significance (if there is one) would require in order to be comprehended a lengthy discussion of the behaviour during growth, not only each of the measurements to be mentioned, but also their relative variations. This is in the process of being realized. At present, therefore, we are limiting ourselves to two considerations. Firstly, we must admit that the method used, analysis by principal components, leads us to ascertain on the one hand, that the younger individuals are equally the shortest further that the older individuals are the tallest (factor 1), and on the other hand that, independently of age, the boys are always different from the girls and that these differences are greater between the older individuals (factor 2). This confirms that the method used can lead to certain evident results which are not even questionable. Therefore, it is worthwhile to examine closely, in Figure 3, the evolution through time of factor 3. First of all, we remark that the age-groups as defined above behave in this respect in an identical manner for both sexes: the mean

value of the function regularly increases up to 15 years of age (low values in 1, medium values in 2 and high values in 3), then decreases for both sexes in the oldest age-group (group 4). When we proceed from group 3 to group 4 this last phenomenon is accompanied by a stabilization of the second function for the girls and by a diminution of the values calculated for the same function for the boys (around 15½—16 years). The interesting observation derived from the examination of the set of points in this Figure 3 is that this suggests that the speed of development of this process is not the same for both sexes: something happens around 5½ years of age that, from the point of view of the third factor results in the fact that the girls between 6 and 7½ years have values that correspond to those calculated for the boys of group 2 (7½—11 years). The girls of group 2 (7½—11 years) are similar to the boys of group 3 (11—15½) in this respect, whereas something happens to the girls between 11 to 15 years (Figure 3) which has no equal among the boys. Lastly, the values become once again identical in group 4 for both sexes. We are aware of the fact that we have used the data from a transversal enquiry. We can, however, question ourselves on the significance of what the analysis of principal components suggests concerning the evolution through time of the interrelationships between a certain number of corporal dimensions.

Authors' address: Dr. MARIA BAKONYI
Prof. Dr. PIERRE MOESCHLER
Dept. Anthropology, University of Geneva
12, rue G. Revilliod CH-1227 Carouge
Switzerland