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INTERRELATIONS BETWEEN SOMATOMETRIC CHARACTERS IN THE CZECH ADULT POPULATION

Virtually all methods for the determination of constitutional types are based on the interrelations between body height, weight and the absolute dimensions of particular parts of the body. In many of these methods the types are assessed by visual inspection alone, but newly introduced methods for determination of somatotypes mostly recognize the inadequacy of subjective evaluations and use somatometry for the typing. But in spite of this only little is known on the degree of interrelationship between individual somatometric characters. Some occasional data on this subject are found in the literature, however, as far as we know, these relations were not studied systematically.

The interrelations between absolute dimensions of all parts of the human body should be taken into consideration, not only for the determination of constitutional types, but equally for design of dress pattern, or of furniture, for the construction of machines etc.

Within the scope of investigations of differences between proportions of the body in the major human races Olivier [1958] calculated correlation coefficients for some somatometric characters in adults of various ethnic groups. Kadanoff [1969] determined the differences between the values of correlation coefficients in a variety of somatometric characters in adult females with low and high body height, as well as in males and females of the same body height [1966]. The relation (r) of body weight and circumference of the forearm to some other bodily characteristics in Swedish males, ranging in age from 50 to 70 years, was studied by Lewin, Jonsson and Jürgens [1973]. Fischer [1964] calculated the relation of penis length to body height in Dutch males.

The interrelations between individual characteristics of the human body were investigated also in children. Coefficients of correlation between the circumference of the neurocranium and body height and sitting height were calculated in French children by Pineau and Vassal [1957] and also in Bulgarian children and adolescents from Plovdiv aged

3-18 years by Karapetrov [1969]. Various data from the literature pertaining to this subject were quoted also by Martin and Saller [1957]. Petrov and Batchvarova [1973] correlated a variety of body characteristics with the length of both extremities and their individual segments in children aged 8 years from Plovdiv. Hajniš, Nováková and Farkaš [1970] determined on the basis of correlation coefficients the relations between certain features of the penis, scrotum and some other characteristics of the body in Czech boys from birth to six years of age. Munroe, Clarke and Heath [1969] correlated certain anthropometric characters and indices with constitutional types in white boys from Oregon, aged twelve years. They used Sheldon's method for the determination of individual types. Calculations are used frequently also for the determination of the relations of some bodily characteristics, especially the height and weight of children, to the same or to some other features in their parents (see, e.g. Česnis, [1970, 1971]) and others.

MATERIAL AND METHODS

Our data recorded for adult Czech probands of both sexes, ranging in age from 17 to 49 years, were used for the investigations of interrelations between twelve body dimensions. From 1964 to 1973 anthropometric studies were carried out on 802 probands at the Centre for Metabolism and Nutrition, IKEM, Prague-Krč. The series comprises 425 females and 377 males. For technical reasons it was not possible to measure all examined dimensions in each individual of either sex; however, all investigated characteristics were measured in sufficient numbers of probands to allow statistical evaluation of their interrelations. The numbers of probands in which both correlated features were measured are presented in tabulations. The present communication deals with the characteristics assessed frequently in biotypological studies, as well as with their interrelations: 1) body height, 2) body weight, 3) shoulder width (a-a), 4) pelvis width (ic-ic), 5) trunk length (sst-sy), 6) the transverse diameter of the chest, 7) normal chest circumference, 8) gluteal circumference, 9) circumference of the arm at the midpoint of the length of the humerus, 10) the largest circumference of the forearm, 11) thigh circumference, 12) calf circumference. The circumferences of the extremities were measured always on the right side. All measurements were carried out by the method described by Martin and Saller [1957].

Correlation coefficients (r), were used for the estimation of the interrelations between individual characteristics mentioned above. Table 1 contains, in addition to the correlation coefficients, the values of their mean error (s_r) and their statistical significance expressed in terms of the t value. The numbers of probands (n) subjected to the studies of these relationships are given in the legend to the table 1.

Tab. 1. Correlation matrix of body measurements: 1. body height (425; 377), 2. body weight (425; 377), 3. biacromial width a-a (419; 377), 4. bicristal width ic-ic (419; 377), 5. trunk length sst-sy (395; 377), 6. transverse diameter of the chest (395; 377), 7. chest circumference (425;377), 8. gluteal circumference (424; 377), 9. upper arm circumference (160; 139), 10. forearm circumference (160; 139), 11. thigh circumference (372; 350), 12. calf circumference (160; 139). Figures in brackets are number of female and male subjects respectively. For each pair of characters coefficient of correlation with its mean error and *t*-value is given

		Men												
		1	2	3	4	5	6	7	8	9	10	11	12	
Women	1	—	0.593 0.041 14.46	0.511 0.044 11.59	0.469 0.045 10.42	0.600 0.041 14.63	0.254 0.049 5.16	0.353 0.051 6.92	0.437 0.046 9.47	0.282 0.081 3.46	0.323 0.080 4.02	0.331 0.050 6.62	0.425 0.077 5.50	
	2	0.492 11.69	—	0.598 0.041 14.58	0.641 0.039 16.43	0.553 0.043 12.83	0.557 0.042 13.26	0.800 0.030 26.66	0.862 0.026 33.11	0.761 0.055 13.81	0.694 0.061 11.36	0.718 0.037 19.37	0.763 0.055 13.87	
	3	0.503 0.042 11.97	0.437 0.044 9.93	—	0.482 0.045 10.71	0.359 0.048 7.45	0.448 0.046 9.73	0.338 0.048 7.02	0.492 0.044 11.18	0.367 0.079 4.63	0.333 0.080 4.16	0.420 0.048 8.75	0.431 0.077 8.75	0.431 0.077 5.58
	4	0.281 0.047 5.95	0.559 0.040 13.95	0.376 0.045 8.35	—	0.413 0.047 8.76	0.374 0.047 7.95	0.534 0.043 12.41	0.601 0.041 14.63	0.516 0.073 7.06	0.430 0.077 5.57	0.440 0.048 9.14	0.510 0.073 6.97	0.510 0.073 6.97
	5	0.578 0.041 14.09	0.283 0.048 5.87	0.361 0.047 7.68	0.292 0.048 6.06	—	0.270 0.049 5.48	0.344 0.048 7.16	0.474 0.045 10.53	0.275 0.082 3.35	0.346 0.080 4.31	0.295 0.051 5.76	0.408 0.078 5.23	0.408 0.078 5.23
	6	0.224 0.049 4.55	0.538 0.042 12.78	0.370 0.046 8.02	0.384 0.046 8.34	0.163 0.049 3.32	—	0.575 0.042 13.69	0.480 0.045 10.64	0.397 0.078 5.08	0.345 0.080 4.30	0.392 0.049 7.97	0.264 0.082 3.20	0.264 0.082 3.20
	7	0.246 0.047 5.23	0.749 0.032 23.37	0.302 0.046 6.54	0.429 0.044 9.75	0.103 0.050 2.04	0.612 0.039 15.69	—	0.753 0.034 22.11	0.656 0.064 10.23	0.578 0.069 8.36	0.609 0.042 14.50	0.655 0.064 10.21	0.655 0.064 10.21
	8	0.273 0.046 5.91	0.844 0.026 32.42	0.326 0.046 7.08	0.507 0.042 12.07	0.134 0.044 2.73	0.455 0.044 10.31	0.674 0.035 19.22	—	0.659 0.064 10.29	0.602 0.068 8.83	0.664 0.040 16.60	0.690 0.061 11.29	0.690 0.061 11.29
	9	0.110 0.079 1.39	0.752 0.052 14.46	0.298 0.076 3.90	0.472 0.070 6.72	0.066 0.077 0.84	0.362 0.074 4.87	0.667 0.051 13.05	0.814 0.046 17.69	—	0.848 0.045 18.82	0.697 0.061 11.40	0.626 0.066 9.48	0.626 0.066 9.48
	10	0.202 0.079 2.55	0.627 0.061 10.27	0.394 0.073 5.39	0.298 0.075 3.97	0.177 0.078 2.25	0.346 0.074 4.66	0.570 0.065 8.76	0.639 0.061 10.45	0.734 0.054 13.57	—	0.608 0.068 7.92	0.619 0.067 9.23	0.619 0.067 9.23
	11	0.192 0.051 3.74	0.748 0.034 22.00	0.302 0.049 6.16	0.375 0.048 7.79	0.078 0.050 1.54	0.385 0.048 8.02	0.573 0.042 13.61	0.828 0.029 28.55	0.811 0.046 17.63	0.626 0.062 10.08	—	0.711 0.060 11.83	0.711 0.060 11.83
	12	0.181 0.078 2.30	0.716 0.055 13.01	0.359 0.074 4.85	0.414 0.072 5.75	0.043 0.079 0.53	0.392 0.073 5.36	0.561 0.066 8.50	0.736 0.053 13.88	0.683 0.058 11.77	0.674 0.058 11.62	0.784 0.049 15.97	—	—

DISCUSSION OF RESULTS

As it was already mentioned in the introduction to our present communication, there are only a few studies dealing with comparison of the interrelation of various dimensions of the human body- especially in adults. Olivier [1958] determined in his study the correlation between the length of both extremities and of their individual segments and body

height, between the length and width of the autopodium of both extremities, between the length of identical segments of the upper and lower extremities, as well as between the length of the extremities and that of the trunk, etc. These studies were carried on males of the three major races, as well as in French women. Some of the calculated correlation coefficients were relatively high (e.g. the relation of the total length of extremities to body height, the relative lengths of the two extremities), while some were middle (relation of the forearm length and arm length, of the thigh and shin length, trunk length and body height, biacromial and bicristal width and body height) and some others were middle to low (relation of the length of the upper extremity to trunk length, of the width of the autopodium to its length, of the length of the lower extremity to the trunk length, of the biacromial and bicristal width to trunk length, of the biacromial to bicristal width, of the circumference of the chest to body height and trunk length. The values of the calculated correlation coefficients between individual characteristics showed a certain relationship to the racial origin of the proband and thus confirmed the well known differences of body proportions among human races.

Correlation coefficients for all pairs of examined characters are presented in table 1. For the purpose of this paper it seems unnecessary to consider each coefficient separately.

As far as our results are comparable with those reported by Olivier, it can be seen that the values of the calculated correlation coefficients are approximately equal in both studies. Our results do not differ substantially from the values obtained for French men and women, as the representants of the white race.

Of the data reported by Kadanoff [1969] in Bulgarian women we can compare with our results only the relation of biacromial and bicristal width to the anterior length of the trunk, of the circumference of the chest and of gluteal circumference to the anterior length of the trunk, of the biacromial to the bicristal width, and of the circumference of the chest to gluteal circumference. While in our series of women the correlation coefficients for the relation of biacromial width to trunk length, and of bicristal width to the normal circumference of the chest, are higher, all other above mentioned relations are approximately the same as those reported in the compared study. The above mentioned study of Kadanoff provided evidence that there are not substantial differences in the degree of the investigated relations between women with high and low body height.

Lewin et al. [1973] mentioned, among other data, in Swedish males aged 50 to 70 years, also the correlation coefficients for the relation of body height to weight and to the circumference of the forearm, and of body weight to the forearm circumference. All three correlation coefficients were calculated separately of the age group 50 - 64 years and

65 - 70 years. Similarly as the difference in body height [Kadanoff 1969], the age exerts obviously no influence on the interrelations between the investigated characteristics. In both age groups described by the above mentioned investigators [Lewin et al., 1973] the correlation coefficients for the relation of body weight to the circumference of the forearm was +0.72 and thus was actually identical with the r value obtained of our males (+0.69). In contrast to this we have ascertained in our series of men a close relation between body height and weight and a slightly closer relation between body height and circumference of the forearm (Lewin et al., [1973]: +0.19, +0.25), see table 1.

It is well known that the interrelations between the dimensions of the separate parts of the human body undergo changes during the process of growth. This results in changes of body proportions, as well as of the investigated interrelations between various somatic features. The comparison of the calculated correlation coefficients for adults, where they are already stable, with those obtained in children, therefore, is not justified, since the data obtained in these two periods of life are not mutually comparable. For this reason our study does not include a comparison with data which we have obtained for infant age.

The mutual comparison of the above mentioned correlation coefficients obtained in our studies yielded a rather surprising result that body weight shows closer relation to all other investigated characteristics than body height. As it was anticipated, this difference is most marked in relation to both circumferences of the body, but is equally evident in relation to all four measured circumferences of the extremities. Biacromial and bicristal widths show a slighter or middle relation to the other characteristics; relation is more marked in pelvis width (but with the exception of body height) than in the width of the shoulders.

Besides body height, and in males also body weight, there is only a slight relation of trunk length, measured between points sst-sy, to all other investigated characteristics. It can be seen that it shows a definite middle relation only to one of the investigated vertical dimensions, i.e. to body height. There is no demonstrable closer relation between trunk length and any of the investigated circumferences — it is of particular interest that this holds true also for the transverse diameter of the chest.

It was anticipated that the transverse diameter of the chest might be related not only to the circumference of the chest, but also to the length of the trunk, and to the widths of the shoulders and of the pelvis as well. It was found, however, that it shows a more marked, though only moderate, relation to the normal circumference of the chest and to body weight. As it was already mentioned, the circumference of the chest has rather close relation to body weight; while it is to some degree equally related to the transverse diameter of the chest and to all other investigated circumferences. However, the correlation coefficient of its relation to the

other circumferences was only in a single case (men — gluteal circumference) higher than the borderline value $+0.7$.

Gluteal circumference shows a marked relation to body weight in both sexes. Its relation to bicristal width is only middle, in spite of the architectural connection with the later dimension. Its relation to the chest circumference and to the circumferences of the extremities ranges from middle to high. A more marked correlation of gluteal circumference to the circumferences of stylo- and zeugopodium of both extremities in females as compared with males, could be due to the differences of fat accumulation in various parts of the human body according to sex. In women there is a more marked relation of the gluteal circumference to that of the arm and thigh, rather than to the circumference of the forearm and calf, while in men the analysis of these relationship failed to yield any uniform pattern. This could further confirm the above mentioned differences of the accumulation of subcutaneous fat according to sex. We failed to disclose any definite relations between gluteal circumference and the other investigated characteristics.

The circumferences of the arm, forearm, thigh and calf are again relatively closely related to body weight and each of them is also related to certain other investigated circumferences. This is obviously due again to the different pattern of skeletal muscles development and distribution in both sexes, as well as to the above mentioned differences of subcutaneous fat accumulation in males and females. The correlation coefficients for the relation of the circumferences of extremities to the normal circumference of the chest are only middle. The relation between the circumference of the forearm and the two investigated circumferences of the lower extremity attain also only middle values.

In women the relation between the circumference of the arm, and that of the forearm is approximately the same as the relation between the circumference of the thigh and of the calf, while in men there is a more marked relation between the circumference of the arm and that of the forearm (see table 1). This could again be explained by the stronger development of the humeral and antebrachial muscles in men as compared to women.

CONCLUSIONS

Our studies on the interrelations between twelve various dimensions of the human body in 802 adult Czech probands (425 women and 377 men) ranging in age from 17 to 49 years yielded the following results:

- 1) Calculated correlation coefficients provided evidence of positive, but only slight or middle interrelations of most investigated somatometric characters. An exception is the relation of body weight to some of

the investigated circumferences, as well as the interrelation between some of the ascertained circumferences of the trunk and of the extremities, where high correlation coefficients were obtained. It can be assumed that the closer relations between these characteristics are caused by higher amounts of fat deposition. Fat is deposited subcutaneously and leads to an increase of body weight associated with an increase of body circumference. All calculated correlation coefficients, but for a few exceptions, were significant at the 0.01 level.

2) We think that of particular importance is the slight interrelation of the major characteristics of the human body warranting their free combinations, because in our opinion determinations of somatotypes should be carried out on the basis of combinations of several somatometric features which are not markedly interrelated (see Hajniš, [1976]).

3) While compared to the other investigated characteristics, body height, weight, biacromial and bicristal widths and trunk length show more marked interrelations in males than in females, just the opposite holds true for the relation of the gluteal circumference to those of the stylo- and zeugopodium of both extremities. This could be possibly due to the varying extent of variability of individual traits according to sex.

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ZALEŻNOŚCI POMIĘDZY CECHAMI SOMATOMETRYCZNYMI U DOROŚLYCH CZECHÓW

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Zbadano grupę złożoną z 802 dorosłych Czechów, w tym 425 kobiet i 377 mężczyzn, w wieku od 17 do 49 lat. Wyniki badań są następujące.

1. Wyliczone współczynniki korelacji między cechami wskazują na dodatnią, lecz słabą (lub średnią) zależność w większości par pomiarów.

2. Wyjątek stanowią związki ciężaru ciała z niektórymi obwodami oraz obwodów tułowia z obwodami kończyn; charakteryzują się one wysokimi współczynnikami korelacji. Wynika to z faktu, że o wartości wspomnianych pomiarów decyduje w znacznym stopniu rozwój tkanki tłuszczowej.

3. Należy zwrócić uwagę na słabe zależności wielu pomiarów ciała ludzkiego — te właśnie pomiary mogą stanowić podstawę dla charakterystyki somatycznej człowieka.

4. W porównaniu z innymi cechami, wysokość, ciężar, szerokość barków, szerokość bioder oraz długość tułowia wykazują wyraźniejsze związki u mężczyzn, niż u kobiet, odwrotnie natomiast przedstawiają się związki między obwodami pośladków oraz stylo- i zeugopodium na obu kończynach. Może to wynikać z różnic w zmienności poszczególnych cech u obu płci.

DÉPENDANCES ENTRE LES TRAITS SOMATOMÉTRIQUES CHEZ LES TCHÈQUES ADULTES

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Un groupe composé de 802 Tchèques adultes, parmi lesquels il y avait 425 femmes et 377 hommes âgés de 17 à 49 ans, a été examiné. Les résultats obtenus sont suivants:

1. Coefficients de corrélation calculés entre des traits démontraient une dépendance positive mais faible (ou bien moyenne) pour la plupart des paires de mensurations.

2. Les relations entre poids et quelques circonférences, ainsi qu'entre les circonférences du tronc et celles des extrémités faisaient exception étant caractérisées par les coefficients de corrélation bien hauts, ce qui résultait du fait que les valeurs de mensurations effectuées dépendaient considérablement du développement du tissu graisseux.

3. Il faut prendre en considération les dépendances bien faibles entre plusieurs mensurations pouvant fournir une base à la caractéristique somatique de l'homme.

4. Par rapport aux autres traits, taille, poids, largeur d'épaule (a-a), largeur de hanches (ic-ic) et longueur de tronc démontraient les dépendances plus nettes chez les hommes que chez les femmes. Au contraire, les relations entre circonférences de fesses et stylo- et zeugopodium des tous deux extrémités étaient faibles. Ce fait peut résulter de différences dans les variations de traits divers chez les tous deux sexes.