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DIFFERENCES OF BODY CHARACTERISTICS IN THE INDIVIDUAL SOMATOTYPES

ABSTRACT: — Student's t-test is used to find out the importance of differences in 16 mean values of directly measured somatometric characters and of the sum of the fitness of 5 skin folds among five somatotypes determined through Wanke's modified method. The authors used for their conclusions the research data of 802 17—49 years old Czech probands (of 425 females and 377 males).

As regards trunk width dimensions, the most varied among various somatotypes is the transversal diameter of the chest. One of the most suitable discriminating criteria is trunk length; of a comparatively very good discriminant quality in both sexes is also the normal chest circumference in both sexes, and the gluteal circumference in females. The circumferences of the limbs in the individual somatotypes do not differ.

It is well demonstrated that in females the total amount of body fat differs according to the somatotype; the same applies to a certain extent also to the individual skin folds subjected to study, as well as to their sum. In males these differences are not so significant.

Since the differences among the female somatotypes are statistically more significant the authors hold that it would be necessary to use a method showing the differences among various somatotypes of males in a more distinct way.

KEY WORDS: Somatotype — Body Fat — Anthropometry.

The existence of two extremely opposite constitutional types in humans, designated by various terms, has been recognized for a long time (e.g. asthenic x digestive type, leptomorph x pyknomorph type, ectomorph x endomorph type a.o. — see e.g. Sigaud 1914, Bunak 1924, Conrad 1941, Sheldon et al. 1954, Kretschmer 1961, Heath and Carter 1967 a.o.), but it was only recently demonstrated biostatistically (Knussman 1968, Howells 1952). Anthropometric studies of extreme somatotypes were reported by Dupertuis (1950).

The number of types determined by individual methods of human constitutional typology which are based on morphologic estimation alone varies — from three to eight (see Bunak 1924, Kretschmer 1961, Sheldon et al. 1954, Škerlj 1959). Their differentiation is linked with considerable difficulties — especially when a large number of types is recognized — and this raises a fundamental question — whether there are actually any other categories of constitutional types, besides the above mentioned and generally accepted leptomorph and pyknomorph types. Thus e.g. Knussmann (1968) questioned the existence of the so-called „athletic type" which obviously corresponds to the mesomorph or muscular type in other systems of constitutional typology.

Yet even if we accept the actual variability of individual characteristics used in the constitutional typology, we must conclude that if somatotypes actually exist, they should be clearly distinguishable.

Methods using statistical criteria for the differentiation of various somatotypes make the determination quite easy (see e.g. Sheldon 1940, Heath and Carter 1967, Wanke 1954, Hajniš et al. 1974, Baumann 1955, Baumann and Jeanneret 1951 a.o.). On the other side it should be realized that when distinct types are devised, e.g. by segmenting the variation order of the individual by investigated characteristics on the bases of standard deviation etc., conceivably this results only in types with an identical range of variations, which is not necessarily present, however, in actual somatotypes encountered in a given population sample.

In addition to the above-mentioned problem the question of the real differences between somatotypes determined by the commonly used grouping of the variation order of fundamental somatomeric characters is considered to be of particular interest. Since these types are essentially artificial, it could be anticipated that real differences will be only small, if any. In order to investigate this problem, the differences between the mean values of characters ascertained by measurements used in Wanke's determination of somatotypes for the calculation of indices (Wanke 1954), as well as of the differences of a series of other characters were tested and the results are reported in the present communication; with the exception of body heigt and weight, as we have stated in one of our earlier papers, including the differences between the values of Rohrer's index (Hajniš, Petrásek, 1975).

Since we have failed to find the available literature in any reports dealing with a comparison of individual constitutional types based on somatometric values, our results are presented without comparison with other data.

MATERIAL AND METHODS

Our data obtained through the examination of 802 adult Czech probands (425 females and 377 males) have been used for the assessment of differences between the mean values ascertained by Wanke's method in the individual somatotypes (Wanke 1954, Hajniš et al. 1974). The age of the individuals examined ranged from 17 to 49 years. Their examinations were carried out throughout 1964—1973 at the Centre for Metabolism and Nutrition of the IKEM, Prague-Krč. The employement of all probands included light or moderately hard type of physical work.

Wanke's method for the determination of somatotypes is based on the grouping of the variation order of five indices according to their standard deviations, as well as on the combinations of their gradation degrees (11111, 11112 ..... 33332, 33333). He uses five somatotypes: leptosome (L), leptomesosome (LM). mesosome (M), mesopyknosome (MP) and pyknosome (P). In our modification of this method (Hajniš et al., 1974) we have substituted the relation between trunk length (sst-sy) and the transverse diameter of the chest which we consider more appropriate for the determination of somatotypes, for the thoracic index calculated from the anteroposterior and transverse diameter of the chest.

The present paper deals with the use of Student's t-test in the assessment of differences between mean values of all dimensions used in Wanke's method and determined by direct measurements in various somatotypes. The length of the trunk, measured between sst-sy points was used, however, in place of the anteroposterior diameter of the chest. The difference between body height and body weight, however, is an exception, as reported in an earlier paper, together with the results of Rohrer's index (Hajniš, Petrásek, 1975). In addition to these dimensions the differences between some other characters, i.e. the circumference of the stylo- and zeugopodium in both extremities, gluteal circumference, the thickness of five skin folds and their total sum and the proportion of fat deposition were tested as well. The results are presented in tables. The investigated circumferences of the extremities and the thickness of skin folds (Best caliper) were measured on the right side of the body. The total amount of body fat was determined by the method of hydrostatic weighing, according to Keys and Brožek (1952).

DIFFERENCES BETWEEN SOME SOMATOMETRIC FEATURES

Since the present report is not concerned with the assessment of absolute mean values, but is aimed primarily at the determination of differences between individual characters, we shall mention in the following the calculated t-values only.

The numbers of probands used in the evaluation of the mutual differences (N — 2) between mean values of all investigated characters in the individual somatotypes are presented in *table 1.*

TABLE 1. *Number of probands investigated for the differences between the somatotypes (N-2)*

		Females				
		L	LM	M	MP	P
Males	L	—	69	214	93	25
	LM	74	—	259	138	70
	M	174	240	—	283	215
	MP	68	134	234	—	94
	P	9	75	175	69	—

Of the tabulated t-values of mean differences (Tab. 2.—18.), those which were significant at the 5 %, 2 %, 1 % and 0.1 % level, were marked by symbols specified under *table 2.*

The comparison of differences between the investigated width dimensions of the trunk, i.e. the

TABLE 2. *T-values of the differences of biacromial width (A-a) between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	1.36	1.15	0.69	1.15
	LM	0.69	—	0.58	1.17	0.12
Males	M	0.36	1.02	—	0.90	0.19
	MP	0.36	2.80 +++	2.27 +	—	0.59
	P	0.34	1.16	0.79	0.01	—

+ Significant at $P_{0.05}$
++ Significant at $P_{0.02}$
+++ Significant at $P_{0.01}$
++++ Significant at $P_{0.001}$

widths of the shoulders (a—a), chest and pelvis (ic—ic) (tab. 2., 3., 4.) between individual somatotypes revealed certain variations. While, even at the $P_{0.05}$ significance level the biacromial width of the shoulder (but for two values, i.e. between MP and LM and between MP and M types in males) never attained significant differences, the bicristal width of the pelvis, on the contrary, showed in some cases statistically significant differences. This holds true in males only for the differences between LM and M and LM and MP types, in females, however, in addition also for the differences between L and MP types and especially between M and MP somatotypes. *Table 3.* illustrates, that some of these differences were significant only at the $P_{0.001}$ level.

TABLE 3. *T-values of the differences of pelvic width (ic-ic) between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	0.52	0.68	2.30+	0.77
	LM	0.54	—	2.42 ++	5.06 ++++	1.62
Males	M	0.40	2.92 +++	—	4.46 ++++	0.53
	MP	0.90	3.93 ++++	1.75	—	1.36
	P	0.58	1.33	0.24	0.36	—

TABLE 4. *T-values of the differences of transversal chest diameter between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	0.44	1.34	2.63 +++	2.10 +
	LM	0.10	—	3.25 +++	4.40 ++++	2.22 +
Males	M	0.85	2.70 +++	—	4.71 ++++	2.59 +++
	MP	1.79	4.62 ++++	1.51	—	0.12
	P	1.46	1.93	0.53	0.05	—

There was even a greater number of statistically significant differences of the transverse diameter of the chest between individual somatotypes in women *(table 4.)*. No differences of this character were found between the two opposite types (L, P) regarding the nearest types (LM, MP), nor between L and M types. In females in other instances appeared statistically significant differences between individual somatotypes. Similarly as in the two previously mentioned width dimensions, the calculated t-values showed a statistically significant difference in t-values above $P_{0.05}$ in males only, namely in two instances (LM × M; LM × MP), i.e. substantially less frequently than in women.

There were highly marked differences of trunk length (sst — sy) between all individual somatotypes. *Table 5.* provides evidence that the differences were in all cases statistically significant, and in

TABLE 5. *T-values of the differences of trunk length (sst-sy) between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	2.31 +	9.14 ++++	8.87 ++++	9.54 ++++
	LM	3.61 ++++	—	3.39 ++++	4.15 ++++	3.43 ++++
Males	M	4.69 ++++	3.01 +++	—	4.72 ++++	6.79 ++++
	MP	6.50 ++++	7.00 ++++	5.31 ++++	—	3.51 ++++
	P	10.39 ++++	5.52 ++++	4.62 ++++	2.85 +++	—

the overwhelming majority of cases even highly statistically significant. These marked differences were most probably due to the diverse body height in various types (see Hajniš, Petrásek, 1975), which is related, to a certain degree, to trunk length (Hajniš et al., 1977). In this connection it should be noted that there are rather high t-values of differences between the two opposite types (L × P) in both sexes. This holds also for some other somatotypes too, where $t > P_{0,000000001}$. As regards of the investigated characters the trunk length showed the most marked differences among the individual somatotypes.

The review of t-values in the assessment of differences of the normal circumference of the chest and of gluteal circumference between individual somatotypes *(tab. 6. and 7.)* revealed an identical situation in females. Similarly as in the transverse diameter of the chest, there were again at the 5 % significance level no differences from the nearest somatotypes only in types L and P (compared to LM and MP), as well as no differences between the L type and M type. All other differences were statistically highly significant and the t-value was nearly in all cases higher than $t_{P_{0,01}}$. In the series of males the tables show slight differences. A compa-

TABLE 6. *T-values of the differences of normal chest circumference between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	0.37	1.61	4.12 ++++	3.77 ++++
	LM	0.69	—	2.50 ++	6.97 ++++	5.20 ++++
Males	M	1.79	3.67 ++++	—	5.86 ++++	3.73 ++++
	MP	2.33 ++	5.12 ++++	2.71 +++	—	0.91
	P	3.03 ++	1.56	0.24	0.65	—

TABLE 7. *T-values of the differences of gluteal circumference between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	0.25	1.42	3.45 ++++	3.02 +++
	LM	0.38	—	3.31 ++++	7.03 ++++	4.86 ++++
Males	M	0.59	3.10 +++	—	6.26 ++++	3.17 +++
	MP	1.27	4.57 ++++	2.37 ++	—	0.03
	P	0.01	0.43	0.64	1.40	—

ratively large number of statistically significant differences between various somatotypes (ranging from $P_{0.02}$ to $P_{0.000001}$) showed the normal circumference of the chest (5) compared to the gluteal region (3). The interesting thing is that similarly as in females there are marked differences in the chest circumference between L and P, and between L and MP somatotypes. There were no significant differences in the gluteal region.

Tables 8.—11. present the t-values of differences in circumference of the stylo- and zeugopodium of both extremities in both sexes. It can be seen that they were very low in all cases. The significance at the $P_{0.05}$ level has not been attained. These findings provide evidence, that it is not possible to use the investigated circumferences of the extremities for the determination of somatotypes.

TABLE 8. *T-values of the differences of arm circumference between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	0.54	0.06	0.12	0.55
	LM	1.11	—	0.96	0.70	0.18
Males	M	1.10	0.06	—	0.15	0.70
	MP	0.98	0.17	0.25	—	0.58
	P	0.52	0.47	0.48	0.37	—

TABLE 9. *T-values of the differences of forearm circumference between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	0.66	0.22	0.34	0.79
	LM	1.12	—	0.91	0.55	0.36
Males	M	1.09	0.06	—	0.31	0.86
	MP	0.96	0.36	0.36	—	0.67
	P	0.52	0.50	0.48	0.34	—

TABLE 10. *T-values of the differences of thigh circumference between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	0.12	0.97	0.55	0.30
	LM	0.35	—	1.56	0.82	0.32
Males	M	0.46	0.88	—	0.40	0.42
	MP	0.37	0.57	0.20	—	0.15
	P	0.84	1.51	0.77	0.77	—

TABLE 11. *T-values of the differences of calf circumference*

		Females				
		L	LM	M	MP	P
	L	—	0.71	0.22	0.26	0.63
	LM	1.08	—	0.98	0.73	0.14
Males	M	1.01	0.21	—	0.14	0.67
	MP	0.74	0.88	0.82	—	0.55
	P	0.49	0.48	0.42	0.13	—

DIFFERENCES OF THE SKIN FOLDS AND OF FAT DEPOSITION

In addition to the above mentioned characteristics our studies included the measurements of the skin folds thickness with Best caliper, realized in five places. They were the skin fold on the musculus triceps brachii, in the subscapular region, on the hip, on the pectoral muscle and on the abdomen. The localization and measurements of the skin folds were made according to Allen et al. (1956). In addition to the skin folds thickness the difference of their total sum and of the fat deposition between individual somatotypes were noted as well.

The review of the *tables 12.—16.* presenting the t-values of the differences between individual skin folds revealed some interesting features. In accordance with the fact, that no significant differences of the arm circumference are found between individual somatotypes, no statistical differences of the skin fold thickness on the musculus triceps brachii were disclosed in exceptional cases only.

TABLE 12. *T-values of the differences of skin fold thickness on the musculus triceps brachii between the samatotypes*

		Females				
		L	LM	M	MP	P
	L	—	1.93	2.55 ++	2.68 +++	0.89
	LM	1.95	—	1.35	2.00 +	0.38
Males	M	2.01 +	1.25	—	1.22	1.10
	MP	1.43	0.19	1.35	—	1.38
	P	1.18	0.34	0.70	0.19	—

TABLE 13. *T-values of the differences of skin fold thickness in the subscapular region between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	1.99 +	2.65 +++	2.81 +++	1.42
	LM	1.81	—	1.67	2.82 +++	0.78
Males	M	2.03 +	2.10 +	—	2.23 +	0.05
	MP	1.34	0.78	0.87	—	0.75
	P	0.76	0.81	1.31	0.76	—

TABLE 14. *T-values of the differences of skin fold thickness in the hip region between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	1.61	2.13 +	2.43 ++	1.14
	LM	1.96 +	—	1.14	2.06	0.62
Males	M	2.18 +	2.38 ++	—	1.52	0.16
	MP	1.56	1.62	0.05	—	0.43
	P	1.30	0.17	0.61	0.43	—

TABLE 15. *T-values of the differences of skin fold thickness with the musculus pectoralis between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	2.40 ++	2.82 +++	2.61 +++	1.58
	LM	0.72	—	1.70	2.76 +++	0.13
Males	M	0.95	1.32	—	2.46 ++	0.74
	MP	0.78	1.40	0.62	—	1.32
	P	0.18	1.19	1.32	1.05	—

This exception is represented by the difference between the L and M, and between the L and MP types in women. Marginal values of significance showed in addition the difference between the LM and MP somatotypes in women and between the L and M somatotypes in men.

Of the remaining four measured skin folds in males only the L somatotype showed at the 5 % significance level thickness differences especially from the M type, but they did not represent a regular situation. Statistically significant differences of the skin fold thickness on the hip and in the subscapular region were found in males between the LM and M somatotypes (table 13. and 14.). None of the other investigated differences attained the biological significance level.

A greater number of statistically significant differences was found in females. The L type differed most markedly from all other somatotypes. These differences were recorded almost regularly with the exception of the P type. The lower significance of the differences between the skin fold thickness could be due to the small number of probands in the two extremely opposite somatic types (the L and P types). Rather regularly occurred a statistically significant difference (ranging from $P_{0.05}$ to $P_{0.001}$) skin fold between LM and MP as well as between M and MP somatotypes. Most marked differences between individual somatotypes in women showed the thickness of the abdominal skin fold, as is illustrated in table 16. In addition to the above-mentioned values there is a significant difference between LM and M somatotypes at the $P_{0.01}$ level.

It is interesting that we failed to disclose any difference in the thickness of the investigated skin folds between the P type and all other somatotypes. This might be again due to the above-mentioned small number of female probands with P somatotype.

TABLE 16. *T-values of the differences of skin fold thickness in the abdominal region between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	2.06 +	2.92 +++	3.09 +++	1.37
	LM	1.73	—	2.60 +++	3.89 ++++	0.86
Males	M	2.00 +	2.33 ++	—	2.92 +++	0.35
	MP	1.42	1.91	0.49	—	1.25
	P	0.92	0.32	0.99	0.77	—

Although it might have been anticipated, that the summation of the differences between single measured skin folds would result in more marked differences between individual somatotypes, the t-values of the differences from the sum of all in-

vestigated skin folds (presented in *table 17*) show that this was not the case. Statistically significant differences occur only between those somatotypes where they were found between the thickness of individual skin folds. While in males the sum of the five skin folds shows significant differences at the 5 % level only between M and L and LM somatotypes, in females the L type differs from all other somatotypes, but with the exception of the P type. The MP somatotype differs equally significantly from all other somatotypes, with the exception of the P type. However both in males and females the P type again did not differ at the $P_{0.05}$ level from other somatotypes.

TABLE 17. *T-values of the sum differences of the skin fold thickness between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	2.11	2.81	3.06	1.29
			+	+++	+++	
	LM	1.86	—	1.87	3.13	0.47
Males	M	2.11	2.11	—	2.37	0.40
		+	+		++	
	MP	1.45	1.28	0.22	—	1.15
	P	0.96	0.42	1.01	0.66	—

Worth noticing are the results in *table 18.*, presenting the t-values of the differences of the total amount of fat deposition between individual somatotypes determined by Wanke's method. While in men differences at the $P_{0.01}$ and $P_{0.001}$ levels were found only between MP type and LM and M types, they occur more frequently in females, where the P and MP somatotypes differ statistically significantly from the L, LM and M types, but not mutually (P × MP). The demonstrated differences may draw attention to possible changes of the amount of nonactiv body mass in several somatotypes ranging from L to P types. However, our calculations of the average fat proportions in individual somatotypes failed to disclose any increase of fat from L to P somatotypes (see Petrásek et al., 1977).

TABLE 18. *T-values of the differences of total body fat between the somatotypes*

		Females				
		L	LM	M	MP	P
	L	—	1.20	1.18	2.44	2.77
					++	+++
	LM	1.87	—	0.26	2.42	2.28
						+
Males	M	1.17	1.53	—	3.65	2.66
					++++	+++
	MP	0.30	3.75	2.65	—	0.70
			++++	+++		
	P	1.50	0.42	0.86	1.74	—

CONCLUSION

From the calculated differences of 17 somatometric characters between individual somatotypes determined by Wanke's method in 802 adult Czech probands, ranging in age from 17 to 49 years, it follows:

1. Of the three investigated width dimensions of the trunk (a—a, ic—ic, transverse diameter of the chest) the most marked variations showed the transverse diameter of the chest, especially in women. The shoulder width is of no value for the discrimination of individual types, while pelvis width has only a marginal value.

2. Trunk length (sst—sy) represents in both sexes a highly reliable criteria for the discrimination of all individual somatotypes.

3. The normal circumference of the chest and gluteal circumferences provide in women rather satisfactory values for the differentiation between individual somatotypes. In males, the differences of gluteal circumference in most cases are not significant not even at the $P_{0.05}$ level. Therefore, in our opinion, the gluteal circumference in the L and P types of males for the determination of somatotypes cannot be used.

4. The circumference of the arm, fore-arm, thigh and calf both in males and females show no statistically significant differences and therefore they cannot be used for the determination of somatotypes.

5. While significant differences of the thickness of individual skin folds as well as of their sum occur in males at the $P_{0.05}$ level only between two of the investigated somatotypes they are more frequent in females. Thus it can be concluded that in females, with the exception of the pyknosome type, there are certain differences between the thickness of individual skin folds, as well as of their sum. The least number of differences which are significant at least at the 95 % level, was found in the skin fold thickness within the region of the musculus triceps brachii.

6. A biostatistically significantly higher amount of total body fat ($t > t_{P_{0,05}}$) compared to other somatotypes was found in MP and P types of females, which showed, however, no mutual differences. Systematic differences did not occur in males; there was only a difference between the MP and the LM and M somatotypes.

7. There is a greater number of statistically significant differences in females compared to males, indicating the occurrence of more distinct forms in females.

8. In some cases the leptosome and pyknosome types showed no statistically significant mutual difference at the $P_{0.05}$ level neither did they differ significantly from the other somatotypes. However it can not be excluded that this observed phenomenon is due to the small numbers of probands within the two extremely opposite somatotypes.

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