THE VALUE OF ANTHROPOMETRIC INDICES IN THE ASSESSMENT OF BODY BUILD.

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THE assessment of a patient's bodily habitus has now become an important part of clinical investigation in many medical fields.

In general medicine, body build has been found to have a significant relationship with such conditions as peptic ulcer and gall-bladder disease (Draper, 1924). In the field of psychiatry body build has been shown to have an association with the type of mental illness, to influence its progress and to determine response to treatment. It has been shown that the linear type of body build in particular, has an affinity with schizophrenia whereas the broad or lateral types of body build tend to be associated more with manic depressive psychosis (Kretschmer, 1921). A broad type of body build in schizophrenia has been found to be associated with a shorter duration of illness than in those with narrow types of habitus (Betz, 1942) and is considered to be a factor of good prognostic significance in the insulin treatment of schizophrenia (Freudenberg, 1941). Further significant relationships between body build, neurosis and personality are referred to later. These findings emphasize the importance of taking into account the physical constitution as an integral part of the total personality both in physical and psychological medicine.

There are two main methods of assessing body build:

1. Somatoscopy.
2. Somatometry.

Somatoscopy is the assessment of a person's bodily habitus by visual impression. It was the method mainly used by Kretschmer (1921) who stated "the tape measure sees nothing." Somatoscopy as a scientific procedure has inherent disadvantages. Firstly it does not lend itself to accurate quantitative assessment and secondly being a subjective procedure there is no certainty of agreement by different observers. The method is therefore unsuitable for most scientific investigations as it does not permit of repetition and validation by other workers.

Somatometry includes anthropometric measurements taken directly on the body or on standardized photographs.

From such measurements various indices of body build have been devized. A comprehensive list of such indices is given by Tucker and Lessa (1940). It would seem that the empirical considerations have determined the construction of many of these indices, some of which are of doubtful validity.

Empiricism has hitherto been unavoidable, as criteria for determining inductively which measurements are most discriminative in delineating physical

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types have been lacking. Many of the indices have been based on typological theories, e.g. Viola's index and modification of it by Wertheimer and Hesketh (1926) are based on the hypothesis of Viola (1933) that the relative growth of limbs and volume of trunk are interdependent. The longer the limbs the smaller the trunk volume and giving a microsplanchnic type, and vice versa, the shorter the limbs the larger the trunk giving the macrosplanchnic type. This hypothesis cannot be regarded as being adequately validated.

If the hypothesis were correct one would expect a high negative correlation between height (or leg length) and trunk volume, i.e. the numerator and denominator of the index. Symphysis height and an index of trunk volume (Sagittal chest diameter × chest diameter transverse × trunk length) was calculated on 100 soldiers and was found to be − 0·147, − ·097. This negative correlation is small and not statistically significant. This finding therefore tends to throw doubt on the validity of the primary assumption underlying Viola's index.

A number of indices have been based on the Kretschmerian theory of types using the subjective criteria thought to be useful in differentiating types.

Some investigations have used a circular method of reasoning. Firstly, contrasting types of physique (e.g. leptosomatic and pyknic) are segregated by visual inspection into groups and measured. The measurements are then compared and those showing the greatest differences used in forming indices. The disadvantage of this method is that it is merely providing an objective method of discriminating individuals subjectively segregated into contrasting groups of bodily architecture and that it cannot prove either the existence or nature of discrete types in the general population. This method has been used to the best advantage by Erik Stromgren (1937), who by the method of Least Squares was able to determine which measurements in combination most efficiently discriminated the types of physique segregated by impression. From this investigation resulted the well known and useful anthropometric index of Stromgren, which is a function of stature, transverse chest diameter, sagittal chest diameter (vide appendix).

The ideal method of approaching the problem, avoiding the above mentioned disadvantages, would seem to involve using the following essential steps:

1. The analysis of the variations in body build in the normal population by objective inductive methods in order to determine whether there is any evidence to support the type theory of body build.

2. The determination of the factors accounting for the variations in body build.

3. The determination of the measurements that correlate most highly with such factors.

4. The combination of these measurements in a convenient and practicable index to measure efficiently bodily habitus.

The technique of Factor Analysis, which had been used with success in the study of intelligence and personality, afforded an inductive approach to the study of the variations in body build and was first used for this purpose by Burt (1937). Burt's pupils, Cohen (1938) and Hammond (1942) carried out similar factorial studies on Jewish and Welsh groups respectively.

Rees and Eysenck (1945) carried out a factorial analysis of the intercorrelations of 20 physical measurements on a group of 200 soldiers successively admitted to Mill Hill Emergency Hospital, London.

Each measurement was correlated with the others, giving a total of 200 intercorrelations. The table of intercorrelations was analysed by Burt's Multiple Factorial technique using the simple summation method. All the measurements were found to be positively correlated, indicating the presence of a general factor determining the absolute magnitude of each measurement. This is a general factor of size determining variations in bodily size as opposed to bodily proportion.

When the effect of this factor was removed from the table of intercorrelations it was found that some measurements were positvely correlated and others negatively. The residual correlations were found to be statistically significant and further analysis revealed a bipolar factor having positive correlation with length measurements and negative correlations with breadth, width and circumferential measurements. This factor determines two contrasting physiques, the relatively long and narrow and the relatively short and broad—corresponding to the linear and lateral types of Stockard (1923) and the "*longiligne*" and "*briviligne*" types of French authors. Factorial analysis therefore demonstrates that there are two main factors responsible for the variations in human physique.

1. Well marked general factor governing growth in all directions.
2. Bipolar factor determining disproportionate growth, preponderantly either in length or breadth.

The findings therefore confirm the existence of tendencies to certain forms of body build in the general population.

The results of the analysis also enable us to discover which measurements correlate most highly with these factors. It was found that suprasternal height and bicristal diameter were most highly saturated with the first factor and stature and transverse chest diameter most highly saturated with the type factor.

Physical typology is a complex subject and the ideal method for its assessment of body type would be the computation of a regression equation of all or many measurements duly weighted according to the type factor. This method is unwieldy as it would involve taking many measurements and carrying out tedious calculations.

For practical purposes it is desirable to have an index containing the least number of measurements compatible with efficiency. In our analysis two measurements were outstanding in their correlation with the type factor, viz.: stature and transverse chest diameter, and they were combined in the following ratio as an index of body build.

$$= \frac{\text{Stature} \times 100}{\text{Transverse chest diameter} \times 6}.$$

Transverse chest diameter was multiplied by 6, as stature on the average is about six times as large as transverse chest diameter and multiplying by 100

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gives a convenient figure with a mean value near 100. This was the index adopted and was found to be useful in practice. Some would prefer using the ratio :

$$\frac{\text{Transverse Chest Diameter}}{\text{Stature}}$$

as the coefficients of variation of these measurements differ.

For similar reasons some statisticians would advocate the use of standard measure in preference to absolute measure. The use of standard measure makes the index of lesser practical usefulness as it complicates its calculation.

In order to determine whether computation in standard measure was desirable, the index value calculated in absolute measure was correlated with its value calculated in standard measure. The tetrachoric correlation coefficient was found to be + ·94. This correlation is so high that the more complicated computation by standard measure is not considered necessary.

A similar factorial investigation of female physique has been carried out by the author and the detailed results will be published later. It was found that female body build could not be measured by a simple ratio of measurements and a regression equation of four measurements was calculated by Aitken's method of pivotal condensation (Thompson, 1939) from the results of factorial analysis.

Regression equation = ·59 stature + ·47 symphysis height − ·31 chest circumference − ·64 hip circumference.

Classification of Physical Types.

The question of the existence of physical types has aroused interest in medical and other fields since Hippocrates described two antithetical types—the habitus phthisicus, a narrow type of body build and thought to be associated with susceptibility to tuberculosis, and a contrasting type, the habitus apoplecticus, regarded as having an association with cardiovascular disorders.

Since this time numerous classifications have appeared, such as the digestive muscular and respiratory cerebral types of Rostan (1828); the rachitic, carcinomatous and scrophulous-phthisical types of Beneke (1878); the digestive, muscular and respiratory cerebral types of Sigaud (1944); Macrosplanchnic, Normosplanchnic and Microsplanchnic types of Viola (1933); the Pyknic, athletic and leptosomatic types of Kretschmer (1921); Endomorphic, Mesomorphic and Ectomorphic types of Sheldon (1940); and the Leptomorphic, Mesomorphic and Eurymorphic types of Rees and Eysenck (1945). The majority of classifications are based on a dichotomy in physique with two antithetical types as extremes and with intermediate types in some classifications.

If we take the above classifications of physical type as indicating the existence of discrete and mutually exclusive types we find little evidence to support this view when we plot the frequency distribution of various indices among normal and other groups.

Fig. 1 shows the frequency distribution of the Rees-Eysenck index among 1,000 soldiers.

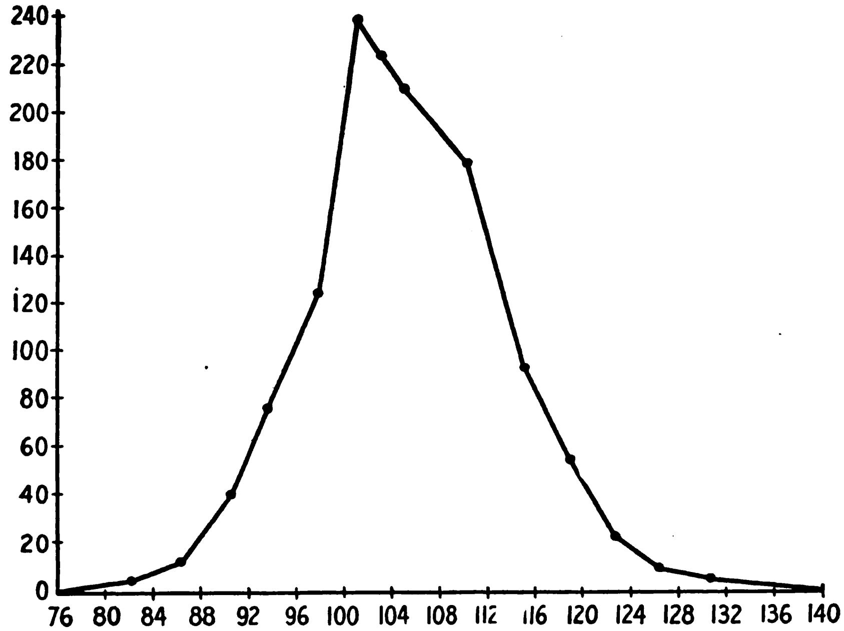

FIG. 1.—Frequency distribution curve of $\frac{\text{Stature} \times 100}{\text{Transverse chest diameter} \times 6}$ index in a group of 1,000 soldiers suffering from neurosis.

It will be seen that the distribution is along a normal curve with some tendency to positive skewness but that there is no evidence of bimodality or multimodality. What we find is a gradual transition from the extreme leptomorph to the extreme eurymorph, that is a continuous variation in physique. The demarcation of physical types is therefore arbitrary and the actual demarcation points taken by us were at one standard deviation above and one standard deviation below the mean.

What we do, in fact, measure by anthropometric indices is a tendency towards certain ranges of body build or the position of the individual in a normally distributed leptomorphic-eurymorphic continuum. This concept emphasizes the futility of using impressionistic diagnosis of physical type for scientific purposes and checking by statistical methods.

Correlation between Various Indices.

Ciocco (1936) pointed out that not only were we ignorant of the principles underlying the construction of various indices but we did not even know the degree to which they correlated with each other.

The calculation of the intercorrelations of various indices is not only of intrinsic interest but in certain circumstances could afford a method of evaluation. Thus, if we could intercorrelate, say 10 different indices taken in a group of individuals, and if these indices were constructed with different measurements, we could carry out a factor analysis on the matrix of intercorrelations. Any significant correlations would presumably be due to a common factor which should in this case be the factor determining somatic habitus, as this is what the indices were supposed to measure. This factor would correspond to the general factor of factorial studies of intelligence. If factorial analysis revealed a general factor it would be possible to determine the saturations of the various indices with this factor. Those indices having the highest saturation with the factor should be the most valid ones in discriminating physical types.

Thirteen indices of body build were calculated on a group of 100 soldiers. Most of the indices were selected from the list given by Tucker and Lessa (1940) and were chosen because they contained the measurements taken on our group. The list therefore does not necessarily comprise a representative sample and it will be seen that many of the indices are made up of similar measurements—stature and chest circumference are included in many indices and this will result in high correlation between these indices. The fact that stature and chest measurements are common to so many indices certainly influences the resulting correlations and these indices will naturally tend to be highly correlated with the general factor. Thus, the method here cannot be used as a means of validation but only as a means of determining the degree of correlation between various indices.

It will be seen from Table I that the Rees-Eysenck index correlates highly with the other indices with a first factor saturation of ·76. The following indices correlate highly with others: Brugsch, Pignet, Stromgren, Wertheimer and Hesketh, Rees and Eysenck, Marburg B. Stature/Sagittal chest diameter

TABLE I.

	Rees-Eysenck Index. 1	Bornhardt, A. Index. 2	Marburg, B. Index. 3	Wigert's Index. 4	Pignet's Index. 5	*Stature*—Sagittal Chest diameter. 6	Wertheimer & Hesketh (Morphological) Index. 7	Rohrer's Index. 8	Brugsh's Index. 9	Lucas & Pryor's Index. 10	Martin's Index. 11	Pignet Ver Vaeck Index. 12	Stromgren Index. 13	First Factor Saturation.
1. Rees-Eysenck Index	0	·36	·66	·64	·68	·71	·75	·04	·78	·011	0	·76	·81	·76
2. Bornhardt, A. Index	·36	0	·51	·29	·53	·31	·40	·42	·55	·21	·11	·65	·33	·56
3. Marburg, B. Index	·66	·51	0	·44	·66	·62	·66	·22	·64	·34	0	·64	·66	·74
4. Wigert's Index	·64	·29	·44	0	·6	·59	·65	·05	·64	·10	·32	·74	·77	·71
5. Pignet's Index	·68	·53	·66	·6	0	·49	·66	·38	·90	·51	·09	·90	·65	·88
6. *Stature* ÷ Sagittal Chest diameter	·71	·31	·62	·59	·49	0	·92	0	·67	·09	·08	·60	·8	·74
7. Wertheimer and Hesketh (Morphological) Index	·75	·40	·66	·65	·66	·92	0	0	·73	·12	0	·76	·81	·80
8. Rohrer's Index	·04	·42	·22	·05	·38	0	0	0	·26	·39	·17	·3	·10	·40
9. Brugsch's Index	·78	·55	·64	·64	·90	·67	·73	·26	0	·32	·12	·90	·68	·90
10. Lucas and Pryor's Index	·01	·21	·34	·10	·51	·09	·12	·39	·32	0	·34	·39	·33	·38
11. Martin's Index	0	·11	0	·32	·09	·08	0	·17	·12	·34	0	·17	·38	·26
12. Pignet Ver Vaeck Index	·76	·65	·64	·74	·90	·60	·76	·30	·90	·39	·17	0	·79	·83
13. Stromgren Index	·81	·33	·66	·77	·65	·80	81	·10	·68	·33	·38	·79	0	·88

and Wigert's index, whereas the indices of Martin, Lucas, Pryor, Rohrer and the Bornhardt A index correlate to a low degree with the others and clearly do not measure the same thing.

Comparison of Indices with Somatoscopic Grading.

The author classified somatoscopically and grouped 100 soldiers into 7 grades according to descriptions given by Kretschmer and others, varying from the extreme pyknic to the extreme leptosome.

Various indices measured independently were correlated with the somatoscopic grading. The Rees-Eysenck index was found to have the highest correlation and had an index of forecasting efficiency of 73 compared with the next best, the Stromgren index which had an index of forecasting efficiency of 42 (Rees and Eysenck, 1945).

Thus the Rees-Eysenck index reproduces the subjective grading of the anthropometric worker more faithfully than other indices, and therefore provides an objective method which can effectively replace somatoscopic grading.

It is not claimed that the Rees-Eysenck index is the most ideal index statistically. As mentioned earlier, a regression equation containing all or most of the measurements would undoubtedly be more accurate, but would be of little value from a practical point of view because of its cumbersome construction and the labour involved in computation.

The ultimate value of any index will be determined by its practical usefulness.

Interesting findings have resulted from the use of the index in the study of personality and neurosis. In an earlier investigation by Rees and Eysenck (1945), a group of 450 soldiers successively admitted to Mill Hill Emergency Hospital were classified by means of the index into leptomorphs, mesomorphs and eurymorphs. It was found that leptomorphs tended to have anxiety, depression and obsessional symptoms, whereas eurymorphs showed a greater tendency to hysterical symptoms. The investigations were extended by the author to a total of 1,100 soldiers and these findings were confirmed.

In a study of effort syndrome, Rees (1943) found that effort syndrome patients, as a group, were more leptomorphic than normal control groups. Furthermore, comparison of leptomorphic effort syndrome patients with eurymorphic effort syndrome patients showed the leptomorphic patients showed greater constitutional predisposition whereas the eurymorphic effort syndrome patients had effort intolerance precipitated usually by extrinsic factors, and was of recent origin as a rule. The leptomorphic patients were of the "constitutional effort syndrome" variety with life-long history of effort intolerance, neuroticism and hypochondriasis.

These interesting correlations between body build and neurosis are not high enough to be of diagnostic value, but indicate the presence of complex inter-relationships between constitutional and extrinsic factors in the development of neurosis and emphasize the importance of taking body build into account in the assessment of total personality in psychiatric illness.

APPENDIX.

Indices of Body Build.

Pignet Index = Stature cm. (chest circumference, cm. + weight, Kgm.)

Morphological Index is a modification of that of Wertheimer and Hesketh (1926):

$$\frac{\text{Symphysis height} \times 10^3}{\text{Transverse chest diameter} \times \text{sagittal chest diameter} \times \text{trunk length}}.$$

Strongren Index = − ·04 stature + ·127 transverse chest diameter + ·56 sagittal chest diameter.

The following indices are quoted by Tucker and Lessa (1940).

Bornhardt, A. $= \dfrac{\text{Stature} \times \text{chest circumference}}{\text{Weight}}.$

Brugsch's Index $= \dfrac{\text{Chest circumference} \times 100}{\text{Stature}}.$

Rohrer $= \dfrac{\text{Weight} \times 100}{\text{Stature} \times \text{shoulder breadth} \times \text{sagittal chest}}.$

Von Rohden $= \dfrac{\text{Symphysis height}}{\text{Chest circumference} \times \text{anterior trunk height}}.$

Lucas and Pryor $= \dfrac{\text{Bi-iliac diameter} \times 1{,}000}{\text{Stature}}.$

Pignet Ver Vaeck $= \dfrac{\text{Weight} + \text{chest circumference} \times 100}{\text{Stature}}.$

Martin $= \dfrac{\text{Bicristal diameter}}{\text{Shoulder breadth}}.$

Marburg, B. $= \dfrac{\text{Leg Length}}{(\text{Transverse} + \text{sagittal chest diameter}) \times \text{trunk length} \times \text{shoulder breadth}}.$

SUMMARY.

1. The methods of assessing somatic habitus are discussed, and the principles underlying the construction of various anthropometric indices are considered.

2. The use of factor analysis as an inductive method for providing relevant data for the construction of indices in the form of ratios and regression equations is described.

3. A simple ratio of stature and transverse chest diameter, based on the results of factorial analysis, was used in a group of 1,100 soldiers and no evidence of types in this sense of descrete and disparate categories was found. Body build was found to be normally distributed along a leptomorphic-eurymorphic continuum in which the individual's position can be ascertained by the index.

4. A selection of anthropometric indices, taken on a group of 100 soldiers, were intercorrelated and factorized. For reasons given the method could not be used for validation, but enabled the degree of correlation between various indices to be measured.

5. Correlation with somatoscopic grading showed that the subjective procedure of somatoscopy can be effectively replaced by the objective method of using the index.

6. The use of the index in the study of personality correlations of physique in effort syndrome and other neurosis patients is described.

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