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Part I.—Original Articles

A FACTORIAL STUDY OF PHYSICAL CONSTITUTION IN WOMEN.

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INTRODUCTION.

THE assessment of body build as an integral part of the total personality is now accepted as an important procedure in the practice of clinical psychiatry. Body build has been found to influence symptomatology, mental status, course and prognosis in neurotic and psychotic disorders (Betz, 1942; Mauz, 1930; Kisselew, 1931; Freudenberg, 1941; Rees, 1945, 1947). Whereas the delineation of physical types has now become an objective procedure by the use of anthropometric indices (Rees, 1949), it has long been recognized that the differentiation of physical types in women is much more difficult. Kretschmer (1921) pointed out that the types of physique described by him were less easily diagnosed in women, and Sheldon (1940) pays comparatively little attention to the variations of female body build.

These difficulties are partly related to anthropometric sex differences, particularly pelvic development, but are mainly due to the fact that scientifically satisfactory analytic procedures have only recently been applied to the study of body build.

The study of body build (somatology) has its roots in antiquity. Hippocrates described two main types of body build, a broad type, the habitus apoplecticus, and a narrow type, the habitus phthisicus, with alleged specific disease susceptibilities as indicated by the names. Galen described various types of body build with particular temperaments which were considered to be determined by various mixtures of the four humours, blood, phlegm, black and yellow bile. The ancient physicians, in fact, appear to have paid more attention to the man as a whole than modern medical practice.

During the past century a great variety of classifications of body build have appeared. The criteria used for categorization differed widely, e.g., morphological concepts governed the classifications of Manoeuvrier (1902), Brugsch (1931), Stockard (1923), and Aschner (1924). Physiological features were emphasized by Rostan (1828), Carus (1852) and Sigaud (1914). Developmental attributes formed the basis of the classifications of Viola (1933) and Sheldon (1940), whereas disease susceptibility was the primary basis of the classifications of Beneke (1878) and Draper (1925).

The majority of the above classifications do not have a scientific basis, and as a rule an inductive approach is lacking.

The fundamental problem of somatology is the determination of the nature of variations in body architecture and the factors underlying such variations. The solution of the problem clearly calls for an inductive approach.

The appropriate method for attacking the problem would be to carry out detailed anthropometric measurements on a random sample of the population, and from the data to determine the nature of the variations and to discover the most scientifically valid and useful way in which the complex variations in body build can be described.

Factorial analysis is a statistical method which is suitable for application to the study of variation in body build, and constitutes a satisfactory objective inductive method of analysis. Factorial analysis was first used in the field of body build by Burt (1938) and subsequently by his pupils Cohen (1938, 1940 and 1941) and Hammond (1942).

Rees and Eysenck (1945) found factorial analysis valuable for determining the nature of variations in physique in a group of 200 male neurotics, and were able to utilize the results in computing an index for studies on physical and personality correlates (Rees, 1944, 1945, 1947).

In view of the fruitful application of factorial analysis to the study of body build in soldiers suffering from neurosis, it was decided to apply the method to the study of physical constitution in women. Accordingly, a factorial analysis was carried out on physical measurements of a group of 200 women service patients with the object of determining—

(1) The factors underlying the variations in female body build.

(2) The most useful, understandable and economical way of describing such variations.

(3) Whether physical types in the sense of mutually exclusive categories existed.

(4) The most useful objective method of assessing body build for clinical investigation and research.

Experimental Population.

The experimental population consists of 400 female service patients, suffering from neurosis, successively admitted to Mill Hill Emergency Hospital. The majority were members of the A.T.S., with some members of the W.A.A.F. and a small number of women of the W.R.N.S. The mean age was 25·01, standard deviation 5·53.

Methodology.

The following anthropometric measurements were taken according to the standardized procedure described by Hrdlicka (1939), Martin (1928) and Wilder (1920); stature, suprasternal height, symphysis height; breadth and length of skull; biacromial diameter, transverse chest diameter; sagittal chest diameter; bicristal diameter; length of sternum; length of arm; chest circumference at full inspiration and full expiration; hip circumference and weight.

Each of the fifteen variables was correlated with the others by means of the tetrachoric method. The matrix of intercorrelations was analysed by Burt's (1941) summation method.

The primary assumption in factor analysis is that when two traits are correlated they can be regarded as being dependent on a common factor. The aim of the analysis is to determine the factors responsible for the intercorrelations of physical measurements. The first step is to determine whether there is a single significant source of variation influencing all the traits in the matrix, i.e., a first common factor of the intercorrelations. The next step is to discover whether other factors exist to account for any residual correlations after the effect of the first common factor is removed. Thus, if it is shown that certain traits tend to cohere in groups, it would be possible to divide the population into types according to the predominance of one or other groups of traits in the individual's physique.

Anthropometric Sex Differences.

It was noted above that at least part of the difficulty in delineating physical types in women was in anthropometric sex differences. It would therefore be of interest to consider the nature and extent of such differences before proceeding to deal with the results of factor analysis.

Table I gives the means and standard deviations of our group of 200 female neurosis patients, together with similar data on groups of neurotic and normal soldiers studied by the author (Rees, 1943). It will be seen that the mean age of the female group is approximately four years less than that of the male groups. While this would not vitiate comparison in skeletal anthropometric dimensions, since skeletal growth would have ceased in all groups, it would, together with the possibility that the groups are not strictly comparable in socio-economic status and other factors, make a detailed statistical comparison inappropriate.

Inspection of the data in Table I will give the general trend of the anthropometric sex differences. It will be noted that the male groups exceed the female groups in all measurements except hip circumference. With regard to length measurements, stature shows approximately 10 cm. mean difference, whereas that in suprasternal height and symphysis height is less, viz., approximately 8 cm. and 5·5 cm. respectively. This indicates a relatively longer trunk length in the female group. Thus we find that, in central tendency, the measurements of the male groups exceed those of the female in all measures except hip circumference. In length measurements the female group has a longer trunk length relative to stature. It will be noted that there is considerable overlapping of all measurements. The reason for these differences in central tendency will be found by reference to studies on growth differentials between the sexes.

Thompson (1946), reviewing the relevant literature, states that boys exceed girls in mean weight until 11 years, and that from 11–14 girls exceed boys, and by 15–16 years superiority is regained by boys, and by 20 years the mean weight of males exceeds that of females by 20 per cent.

Girls, although smaller, tend to be more mature than boys, as indicated by earlier puberty, more rapid skeletal development and earlier pre-adolescent growth spurt. In males from puberty to maturity the growth of trunk and limbs is at first equal; then there follows a period of rapid trunk growth with circumferential growth continuing longer than growth in length.

In females, from puberty to maturity, the trunk elongates in the lumbar region and the pelvis enlarges, while the lower extremities cease to grow in proportion to the trunk.

These sex differentials in physical growth will give rise to differences in central tendency of anthropometric measurements in adults, and would explain differences noted between our male and female groups.

These findings suggest that it would be inappropriate to apply body build indices derived from studies of male subjects to women, and strongly indicates that a special analysis of female body build must be made in order to derive appropriate body-build indices for women.

TABLE I.

	200 auxiliaries.		100 normal soldiers.		200 neurotic soldiers.	
	Mean.	Standard deviation.	Mean.	Standard deviation.	Mean.	Standard deviation.
Age	25·01	5·53	29·27	6·06	28·85	0·589
Stature	161·29	6·262	171·01	5·326	170·91	6·77
Suprasternal height	131·17	5·476	139·47	4·678	139·39	5·78
Symphysis height	80·95	4·641	86·39	4·55	86·51	4·81
Breadth of skull	13·34	0·568	15·27	0·52	14·92	0·58
Length of skull	17·31	0·844	19·59	0·658	19·21	0·66
Biacromial diameter	33·53	1·997	39·61	2·109	38·8	1·68
Transverse chest diameter	23·52	1·556	28·77	2·12	27·95	1·85
Saggital chest diameter	17·24	1·206	20·6	1·633	20·39	1·58
Bicristal diameter	24·13	1·654	29·08	1·59	28·76	1·61
Length of sternum	16·30	1·118	21·89	2·23	21·2	1·78
Chest circumference (at inspiration)	89·16	6·190	95·79	4·87	92·2	3·57
Chest circumference (at expiration)	82·86	6·533	87·96	5·30	86·5	4·5
Hip circumference	82·86	6·533	79·93	6·64	80·2	5·27
Weight	55·74	7·710	65·0	6·887	64·6	7·22

FACTORIAL ANALYSIS RESULTS.

The matrix of intercorrelations of the fifteen variables on a group of 200 women service patients suffering from neurosis successively admitted to Mill Hill Emergency Hospital is shown in Table II.

It will be seen at once that all the measurements are positively correlated, indicating the presence of a general factor. The saturation of each measurement with the first factor, calculated by Burt's summation method, is shown in Table III. When the effect of the first factor is removed from the correlations we are left with the first factor residual correlations. These residuals varied from –·33 to + ·50. The correlations were statistically significant, and

TABLE II.

	Stature.	Supra-sternal height.	Symphysis height.	Breadth of skull.	Length of skull.	Biacromial diameter.	Transverse chest diameter.	Sagittal chest diameter.	Bicristal diameter.	Length of sternum.	Length of arm.	Chest circumference (inspiration).	Chest circumference (expiration).	Hip circumference.	Weight.
ure	—	·9521	·8957	·1098	·2860	·4529	·2668	·3335	·2668	·5480	·7174	·1987	·3146	·3429	·4969
asternal height	·9521	—	·8360	·0200	·3241	·4794	·2377	·3616	·3241	·5227	·7833	·3429	·4259	·1987	·6518
physis height	·8957	·8360	—	·1889	·4168	·3616	·1494	·2764	·1889	·3616	·8249	·1790	·0998	·1889	·3429
dth of skull	·1098	·0200	·1889	—	·0500	·2764	·2280	0	·1889	·1593	·0300	·2280	·1889	·2860	·1593
gth of skull	·2860	·3241	·4168	·0500	—	·4529	·1593	·3051	·2860	·1692	·1987	·1494	·1692	·0200	·3051
romial diameter	·4529	·4794	·3616	·2764	·4259	—	·4881	·3523	·2085	·3335	·4618	·4259	·5480	·3523	·3595
sverse chest diameter	·2668	·2377	·1494	·2280	·1593	·4881	—	·2764	·2571	·1296	·2474	·5891	·5563	·4529	·6594
ttal chest diameter	·3335	·3616	·2764	0	·3051	·3523	·2764	—	·3802	·4969	·4259	·6816	·6131	·6594	·6518
istal diameter	·2668	·3241	·1889	·1889	·2860	·2085	·2571	·3802	—	·3894	·4618	·3146	·4706	·6816	·4349
gth of sternum	·5480	·5227	·3616	·1593	·1692	·3335	·1296	·4969	·3894	—	·3894	·3146	·2860	·3802	·3802
gth of arm	·7174	·7833	·8249	·0300	·1987	·4618	·2474	·4259	·4618	·3894	—	·3241	·2474	·3241	·3709
t circumference (inspiration)	·1987	·3429	·1790	·2280	·1494	·4259	·5891	·6816	·3146	·3146	·3241	—	·8912	·6961	·8076
t circumference (expiration)	·3146	·4259	·0998	·1889	·1692	·5480	·5563	·6131	·4706	·2860	·2474	·8912	—	·7103	·7446
circumference	·3429	·1987	·1889	·2860	·0200	·3523	·4529	·6594	·8616	·3802	·3241	·6961	·7103	—	·7103
ht	·4969	·6518	·3249	·1593	·3051	·5395	·6594	·6518	·4349	·3802	·3709	·8076	·7466	·7103	—

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TABLE III.

	First factor saturation.	Second factor saturation.
1. Stature	0·71	0·64
2. Suprasternal height	0·76	0·52
3. Symphysis height	0·56	0·74
4. Breadth of skull	0·11	−0·2
5. Length of skull	0·36	0·14
6. Biacromial diameter	0·67	0·04
7. Transverse chest diameter	0·54	−0·26
8. Sagittal chest diameter	0·68	−0·14
9. Bicristal diameter	0·56	−0·11
10. Length of sternum	0·56	0·10
11. Length of arm	0·68	0·42
12. Chest circumference (at inspiration)	0·72	−0·52
13. Chest circumference (at expiration)	0·74	−0·48
14. Hip circumference	0·70	−0·56
15. Weight	0·86	−0·26

it is clear that there remains something in common between traits after removal of the effect of the first factor.

The saturation of each measurement with the second factor was calculated by a similar process and is shown in Table III.

The second factor residuals were too small to make further analysis profitable. We find, therefore, that two factors are mainly responsible for the variations in female body build. The first factor accounts for 41 per cent. of the variance and the second factor 16 per cent.

DESCRIPTION OF THE FACTORS.

The first factor has positive correlations with all traits and is clearly a general factor determining body size. This factor accounts for the variation in size as opposed to physical proportions. So far we can only classify the group according to bodily size. If we take single measurements to discriminate individuals in respect to general bulk or size, weight, suprasternal height, stature, chest and hip circumference will be the most informative. Such measurements as bicristal diameter and length of sternum and skull measurements will be of little use for this purpose because of their comparatively low saturation with the first factor.

The removal of the contribution of the first factor, in effect, reduces the members of the group to the same general scale of size and enables the effect of the second factor to be ascertained.

Second factor.—From Fig. 1 and Table III it will be seen that some measurements have positive saturations and others negative saturations with this factor. The second factor is bipolar, having positive saturations for length measurements and negative saturations for breadth, width and circumferential measurements. The effect of this factor is that when length measurements are relatively large there will be relative deficiency in size of breadth and circumferential

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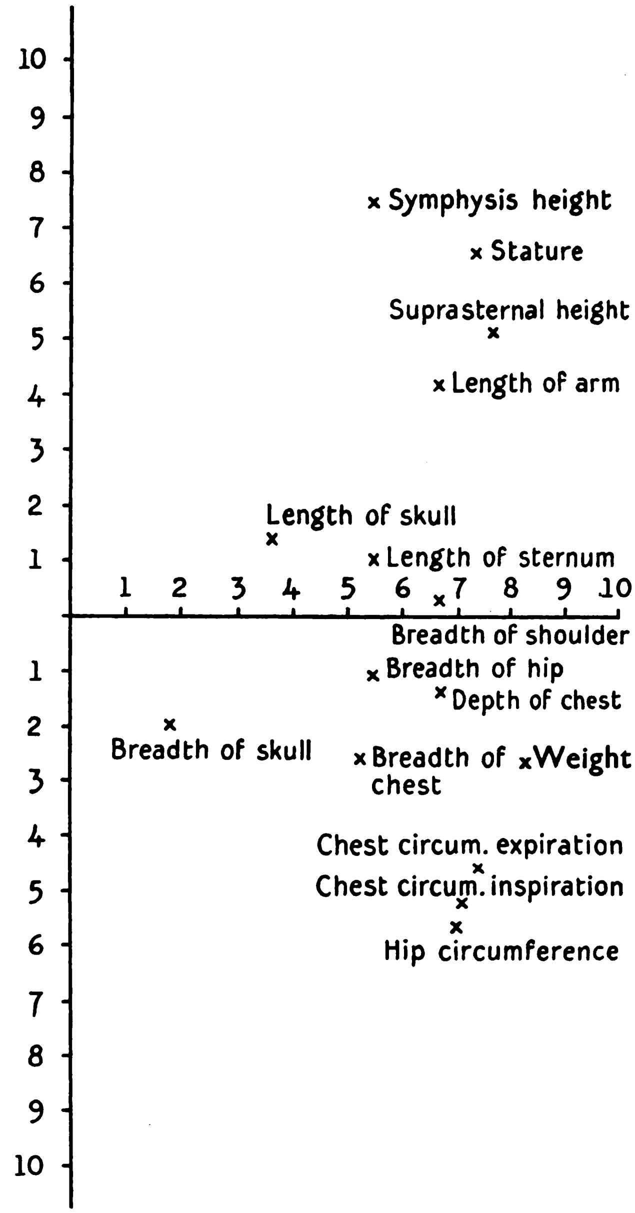

FIG. 1.—Saturation of anthropometric measurements with general and type factors.

measurements. Similarly, when breadth measurements are great, length measurements will tend to be relatively shorter. Some individuals will therefore be characterized by being broad relative to length and others slender relative to length.

This factor would therefore tend to create two antithetical types of bodily architecture, viz., a narrow, linear or leptomorph type and a broad, lateral or eurymorph type.

It is interesting to note that many authors during the past century have, unknown to each other, described more or less corresponding types of physique, although differing in nomenclature and basic criteria, with a general tendency to describe a dichotomy, as above, with intermediate types in some classifications.

Relationship of Factors to Growth.

Factors elicited by factorial analysis are mathematical expressions of underlying processes which determine (*a*) body size and (*b*) body type.

Factorial analysis alone will not tell us whether the processes mathematically expressed by the factors are of genotypical rather than of phenotypical significance. There is, however, considerable evidence that the two factors revealed by factorial analysis correspond to well-defined growth processes.

Carter and Krause (1936) analysing data of Bakwen and Bakwen (1934) on neonates found that all physical measurements correlated positively, indicating the presence of a general factor at the beginning of extra-uterine life. Bayley and Davies (1935) in a study of growth during the first three years of life found evidence of a general growth factor which retarded rapidly at first, then more slowly throughout the 36 months. They found that disproportionate growth occurred at certain periods corresponding to changes in body build. Lateral growth giving rise to chubbiness rapidly increased during the first 11 months, with gradual increase of longitudinal growth after this age. These findings correspond closely to our two factors.

Mullen (1940), in a factorial study of anthropometric measurements of groups of girls of various age groups from 7–17, found in all groups a general factor and two group factors, the latter corresponding to our bipolar factor.

McCloy (1940) analysed physical measurements in groups of boys and girls at various ages from birth to puberty, and also found evidence of a general factor as well as type factors.

Thus our discovery of two main factors underlying the variations of physique in our group of adult women is confirmed by the elicitation of similar factors in groups of children of each sex from birth to maturity.

Similar factors have been found in adult groups in British soldiers (Rees and Eysenck, 1945) and in other adult groups of various racial compositions (Cohen, 1938, 1940 and 1941; Hammond, 1942).

The striking consistency of the findings of factorial analysis in widely differing groups suggests that the factors are of fundamental significance.

General observations on growth in children also lend support to the presence of type factors as well as general factors of growth. Harris (1948) describes growth in childhood as a succession of "springing up" periods alternating with "filling out" periods, which is, indeed, a graphic description of the operation of the type factor. Even in the animal kingdom, growth, according to Huxley (1932), is of two main kinds:

(*a*) Isogonic—general growth,

(*b*) Heterogonic—differential growth,

which appear to correspond respectively to the operation of our first factor governing general growth and to our type factor governing disproportionate growth. These findings suggest the universality of two fundamental growth processes corresponding to our mathematical factors. Presumably such growth processes would be mainly genetically determined, and in this connection it is interesting to note that Krogman (1940) expresses the view that bodily growth is controlled by at least two sets of genetic factors, the first governing general dimensional growth, and the second purely linear or purely circumferential dimensions.

Construction of an Index of Body Build.

The results of factorial analysis provide us with the relevant information for the construction of indices of body build. In the past many body-build indices have been constructed empirically and a number lack any scientific basis.

The measurements that are likely to be useful in discriminating physical types will be those with high saturations with the type factor and, conversely, those with low saturations will be valueless for use in body-build indices.

An index of body build to be useful in clinical practice and research should have the following attributes: (1) Validity; (2) reliability; (3) objectivity; (4) practicability.

Validity.

The validity of an index can be assessed by—

(*a*) Its correlation with other indices.
(*b*) Criteria derived from the results of factorial analysis.

Theoretically it would be possible to determine the validity of various body-build indices by intercorrelating each index with the other and determining the saturation of each index with the first common factor, which in this case would presumably be what each index purports to have in common, viz., the measurement of body build. This method was carried out in male groups (Rees, 1949) and was found to be unsuitable because of the spuriously high correlations produced by the inclusion of the same measurement in many of the well-known indices.

A more satisfactory method of validation is afforded by the results of factor analysis because the degree of saturation with the type factor will indicate the discriminating value of various measures in detecting body types. Thus the validity of an index may be judged by the degree to which the component variables are saturated with the type factor and the manner in which they are combined.

Reliability and Objectivity.

By the reliability of a body-build index we mean the degree of consistency obtained by repetition within a comparatively short period of time. The retest reliability of body build indices is high because the reliability of the majority of anthropometric measurements is high. Objectivity is readily achieved when measurements are taken according to strictly standardized procedures.

Practicability.

For practical purposes the simpler the index the better, providing that efficiency is not thereby sacrificed. In the case of males simplicity was readily achieved, because two measures only were outstanding in their saturation with the type factor (Rees and Eysenck, 1945), and it was possible to use a simple ratio of the two measurements. Even computation in standard measure could be dispensed with as the correlation of the index calculated in absolute measure with its calculation in standard measure was + ·94 (Rees, 1949).

A New Index of Female Body Build.

Inspection of Fig. 1 and Table III will reveal that in our female group there are four measurements with relatively high saturation with the type factor, viz.,

Stature	+ ·64
Symphysis height	+ ·74
Hip circumference	− ·56
Chest circumference	− ·52

The fact that there are four measurements with relatively high saturation with the type factor, and therefore the ones most useful for inclusion in a body-build index, precludes the computation of a simple ratio as an index of female body build.

From a statistical point of view the ideal index of body build would be a regression equation containing all the anthropometric measurements weighted according to the type factor. Such an index, however, would be very cumbersome and would involve tedious calculation.

It was therefore decided to limit the regression equation to the above four measurements having the highest saturation with the type factor. By means of Aiken's method of pivotal condensation (Thompson, 1939), a regression equation of the four measurements weighted according to saturation with the type factor was calculated. The resulting equation for female body build was as follows:

Index of female body build = + ·59 stature + ·47 symphysis height − ·31 chest circumference − ·64 hip circumference.

The measurements in the regression equation are expressed in standard measure.

The index should now be considered with regard to the above-mentioned prerequisites of an index of body build.

The validity of the index should be high, because the selection of measurements and the manner of combination and weighting into a regression equation was governed by the results of the inductive method of factor analysis, which appears to be our best method of validation.

Reliability and objectivity are achieved because the anthropometric measurements used have a high retest reliability and are taken according to standardized methods.

While simplicity has practical advantages, it must not be derived at the expense of validity and efficiency. In the female group under consideration it was not feasible to devise a simple ratio as body-build index as in the male group (Rees and Eysenck, 1945). Whilst ideally a regression equation should contain all the measurements duly weighted according to correlation with the type factor, this would make the index very complicated and difficult to compute. Accordingly the equation was limited to the four measurements having the highest saturation with the type factor. It was considered that further simplification could not be achieved without loss of validity and efficiency.

Frequency Distribution of the New Index of Female Body Build.

The index was calculated for 400 female service neurosis patients successively admitted to Mill Hill Emergency Hospital. The mean was found to be + 1·385 and standard deviation ± 3·68. The frequency distribution curve of the index in the group is shown in Fig. 2. It will be seen that the distribution of the index of female body build is along a normal frequency curve with some tendency to positive skewness. We find a continuous variation in physique, from a broad (eurymorphic) type with high index values at one extreme to the other extreme with a narrow (leptomorph) type with low index values.

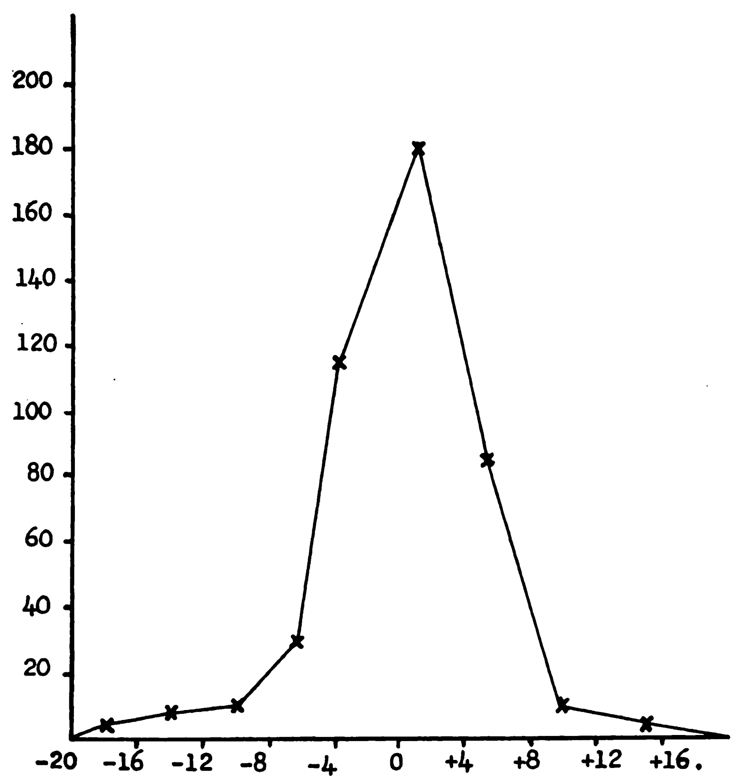

Fig. 2.—Frequency distribution curve of a new index of body build in a group of 400 women.

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We find, as in the male group, a leptomorphic-eurymorphic continuum in a unimodal curve. There is no evidence of any bimodality or multimodality which would be an indication of physical types in the sense of discrete and mutually exclusive categories. The index, therefore, measures the position of the individual in the normal distribution curve of body build. The extremes of the curve only, impress us as well marked and antithetical types. There are no natural dividing points, and any division of the curve into physical types, although convenient and at times necessary for purposes of research, will be arbitrary. A statistically acceptable arbitrary demarcation point would be one standard deviation above and below the mean dividing the curve into three classes.

The three classes are demarcated as follows:

1. *Leptomorphs* with small breadth, width and circumferential measurements relative to length. Index values + ·5·0 and higher.

2. *Eurymorphs* with high circumferential measurements relative to length. Index values − 2·59 and less.

3. *Mesomorphs* with an intermediate relationship between lateral and linear measurements. Index values between − 2·59 and + ·5·0.

This division of the normal frequency distribution of body build is not in any way intended to convey the impression that these classes are disparate types. These categories of physique are ranges of body build objectively measured by a new index of female body build, and demarcated by a statistical criterion for purposes of description and research.

Summary.

1. The paper describes a factorial analysis of the intercorrelations of 15 anthropometric variables in a group of 200 service women neurosis patients successively admitted to Mill Hill Emergency Hospital.

2. The criteria used in the past for classifying body build are described, and the need for an inductive approach emphasized. The difficulties encountered in classifying female body build are discussed, and anthropometric sex differences considered in the light of a comparison of male and female groups and sex growth differentials.

3. The matrix of tetrachoric correlations of the 15 anthropometric variables was analysed by Burt's summation method and two main factors were extracted:

(*a*) General factor influencing growth in all directions and accounting for 41 per cent. of the variance.

(*b*) Type factor which was bipolar, having positive saturation with length measurements and negative saturation with breadth, width and circumferential dimensions. This factor accounted for 16 per cent. of the variance, and is the factor responsible for the existence of two antithetical types of body build, the narrow or leptomorph and the broad or eurymorph type.

4. The relationship of the factors to growth processes is considered in relationship to physical development of children at various ages, types of growth in animal kingdom and genetic aspects.

5. The prerequisites of a body-build index are described. Utilizing the results of factor analysis, the following measurements were selected for inclusion in a body build index because of their high saturation with the type factor: Stature, symphysis height, chest and hip circumference.

A regression equation containing the four measurements duly weighted according to saturation with the type factor was calculated as follows: Index of female body build $= + \cdot 59$ stature $+ \cdot 47$ symphysis height $- \cdot 31$ chest circumference $- \cdot 64$ hip circumference.

6. The new index of female body build was calculated in a group of 400 women service neurosis patients. The frequency distribution curve of the index was normal and unimodal, indicating a continuous variation in physique, therefore lending no support to the theory of the existence of discrete physical types.

7. Using demarcation points at one standard deviation below the mean the frequency distribution curve was divided into—

(1) Leptomorphs with index value $+ 5 \cdot 0$ and higher.
(2) Mesomorphs $-2 \cdot 59$ to $+ \cdot 5 \cdot 0$.
(3) Eurymorphs $-2 \cdot 59$ and less.

These ranges of physique, being capable of objective delineation by the new index of body build, afford convenient body-type classes for clinical practice and research.

Acknowldgements.

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