

# EDUCATIONAL REVIEW

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## II

### THE USE OF ANTHROPOMETRICAL MEASUREMENTS IN SCHOOLS

The time in which we now live will always be memorable as the beginning of a great educational reform. It has seen the complete demonstration of a law which is causing a revolution in educational methods; the law that, in the average, the physical strength of the child and his power to do school work go hand in hand. It has seen the partial introduction of systematic measurements of children and the systematic employment of these measurements in fitting school work to the pupil's strength. It will yet see the universal adoption of this rational and beneficent principle.

It is therefore of the first importance that the ideas which underlie the physical measurement of children should be clearly understood, and that the limitations of the methods by which these measurements may be applied practically should be distinctly recognized. And this is the more important because the methods in question are of only approximate correctness and are thus open to attack by those who would discredit the whole movement, forgetting, in their zeal for flawless methods, that even an imperfect tool may serve a pressing need.

The use of anthropometrical measurements in schools rests on the fundamental truth that the average or other central value of a group of properly related measurements gives an idea of the character of the group. Thus, the average height of boys aged nine affords a basis for a mental picture of the height of all boys of that age. The central value adopted becomes in this way the type of the objects measured.

The central value gives in itself no information concerning the degree in which the individuals of the group differ from the central value. Common observation, however, teaches that giants and dwarfs are rare and that the physical dimen-

sions of children of the same age differ within relatively narrow limits. The central value comes thus to include the conception that extreme deviations are infrequent and that most of the individual measurements in the group lie near the central value. This materially strengthens the idea of type.

The type-value thus developed is found to increase in size from year to year, according to a definite law. Thus the type or central value at age ten is larger than at age seven. Sexual differences are also established. It is found that the central value for girls up to age twelve and after age fourteen is less than for boys of the same age, while from age twelve to age fifteen it is greater. This fact is expressed by saying that during these years the typical girl is larger than the typical boy.

It cannot be too strongly insisted that the laws just mentioned are the laws of growth of the type and not necessarily the laws of individual growth. Yet the fundamental conception of central value or type permits their application to individuals within certain limits. It has already been pointed out that the type idea includes the conception that most of the individuals in the group lie near the central value. It has been said also that the central value of both sexes increases from year to year and that the central value for girls during the ages twelve to fifteen is larger than that for boys. The first and second of these truths enable us to say that the chances are that any individual boy or girl will increase in size from year to year. The first and third justify the statement that if a boy and girl of the same age are selected at random, the chances are that the boy will be larger than the girl except during the ages twelve to fifteen.

The fundamental conception of type permits us to go further. The central value of the whole number of boys or girls at any age is typical of that whole number. The individuals above the central value form a group of larger, and those below a group of smaller children. The two groups stand in our minds, by deduction from the fundamental idea of type, as large and small children. Then the central value of the upper

group will be typical of large children, and the central value of the lower typical of small children.

The central values of the two groups, at each year in the period of growth, convey an idea of the size of large and small children respectively at each year. The increase in these central values from year to year cannot, however, by deduction from the fundamental idea of type, be termed the growth of the typically large and the typically small child. The fundamental idea limits us strictly to the central values of large and small children at any one year. This limitation becomes clear at once when it is remembered that, although the fundamental idea of type includes the conception that an individual selected by chance will seldom vary greatly from the central value, it does not give any information whatever as to the direction of the variation, whether above or below the central value. Consequently, it cannot be said, as a deduction from the fundamental idea of type, that an individual found above the central value of the whole number at any age will be found above the central value of the whole number at any subsequent age. The side of the central value of the whole number on which he may be found cannot be inferred from the fundamental idea of type. Those who, like myself, have written of the growth of the typically large and typically small child have assumed that children remain approximately at the same distance from the central value of their age and sex throughout their period of growth. They have assumed, for example, that a boy who at age seven is above the central value of his age will probably remain above; in other words, that large boys usually grow to be large men. This assumption has evidently no necessary connection with the fundamental idea of type. Its present justification is derived from the very general opinion that violent oscillations in the growth of the individual are on the whole uncommon. The importance of testing this belief by annual measurements of the same children, and the use to which the information thus secured could be put in predicting future growth, will be presently made clear.

The division of the whole number at any age into those

above and those below the central value suggests a farther division. This is well accomplished by the method of Francis Galton, according to which the individuals at any age are arranged in order, from the smallest to the largest, and divided into percentile grades. The relation between the size of any child and the size of other children of the series measured may thus be known. It may be found, for example, that a boy is taller than forty per cent. of the other boys measured at his age and not so tall as sixty per cent. If the series measured is very large, the observation may be safely generalized and the boy declared taller than forty per cent. of all boys of his age, race, and social condition. Percentile grades find therefore an important and legitimate use in determining percentile rank at any year.

Percentile grades cannot, as yet, be used for prediction of future size. It cannot, for example, be positively said that a boy who at age ten is heavier than seventy per cent. of boys of his age will at age fifteen be heavier than seventy per cent. of boys at that age. The objection to such a statement has already been pointed out in the remarks on the central values of the groups of large and small children. The objection is that it is not positively known whether the individual remains in the same percentile grade, *i. e.*, at the same distance from the central value, from year to year. But this limitation, I may once more insist, does not affect the use of percentile grades to determine percentile rank in any one year.

There is much difference of opinion as to what should be taken for the central value. The use of the average (arithmetical mean) to express the fundamental idea of type is an immemorial custom. Quetelet, having demonstrated that children's heights and weights at any age were distributed about the central value approximately in the form of a probability curve, and believing, incorrectly, that the distribution of an infinite number of measurements would be perfectly symmetrical, chose the most frequent value (*value moyenne*). Galton has proposed the fifty percentile grade (median value), and Boas has recently advocated a fourth value, which takes

account of the fact that the distribution curve at any age is not perfectly symmetrical. The most frequent value is now seldom or never used. Almost all investigators have employed the average. Some have based their work on both average and fifty percentile grade.

In this state of uncertainty as to which of these values most nearly represents the true type, it is necessary to determine whether the differences between them are large enough to cause a serious error in their practical use. Dr. Bowditch and I have shown that the difference between median and average values is small, where a large number of measurements is made. The difference between the average and Boas's value is also small. These facts justify the belief that the difference between any one of these three values and the true type is without practical importance. For the difference between the average, for example, and the true type value is very much less than the error which unavoidably accompanies the attempt to fix the relation of a growing child to the type child, and, for practical purposes, may therefore be neglected. For the present, then, the average, or, if the number of measurements is large, the fifty percentile grade, may for practical purposes be taken as a sufficiently close approximation of the true type value.

The sharp discussion concerning the value which should be taken as the type has perhaps given this question undue importance in the eyes of the practical educator. For the theory of statistics the question is indeed of great importance, but it does not particularly affect the use of anthropometrical measurements in schools.

The use of anthropometrical measurements in schools finds its best justification in the acknowledged or tacitly accepted truths that the work required of the pupil of average strength cannot be done without injury by the pupil of less than average strength, and that the strength of children can be estimated from physical measurements. The problem, then, is to divide pupils into two physical grades: the first including those whose physical development makes it probable that they can do the

usual school work of their age without injury ; the second, those whose physical development makes it probable that they cannot do this work without injury, and who therefore demand special care and watchfulness.

The physical measurements which are to serve as the basis of this division should be, for economic reasons, the fewest possible consistent with the end in view. It is generally believed that the ratio between weight and height is the best easily determinable measure of strength in dealing with great numbers of individuals. The practice of life insurance companies, and of many "physical trainers," support this statement. The division may therefore be made on the basis of the ratio of weight to height. The principle of division should be the following: Of 1000 boys of the same age 500 will fall between the seventy-five and the twenty-five percentile grades. The weights of this central 500 will be the usual, and hence presumably normal, weights of boys of that age. The chances are one against one, that the weight of any boy of that age, selected by chance, will fall within the limits mentioned. If the weight of the boy is greater than the seventy-five or less than the twenty-five percentile grade, the chances are that the weight is unusual and therefore abnormal. The greater the deviation, the greater the probability that the weight is abnormal. The line which separates the probably normal weight from the probably abnormal weight may therefore be drawn at the seventy-five and the twenty-five percentile grades. The same considerations hold good for height and for the ratio of weight to height. This ratio should undoubtedly be derived from the seventy-five and twenty-five percentile grades of the weight to height ratios of a great number of children at each age. Such material is, however, not yet collected in sufficient quantity. For the present, therefore, it will be necessary to find these ratios by dividing the values at the percentile grades of weight by the values at the percentile grades of height. The difference in the methods is probably not of great practical importance.

It will not escape notice that these operations are carried



out without the use of the central value, and that the practical educator is thus not directly concerned in the controversy over the central value. For the present, at least, the height to weight ratio at the seventy-five and twenty-five percentile grades will serve his purpose.

I say "for the present," because the future should bring a great advance in the use of anthropometrical measurements in schools. It has already been several times insisted that the data in our possession do not suffice for certain prediction of future growth. In other words, this material does not determine with exactness the rate of growth of the individual. The present data have been collected by the generalizing method, that is, by measuring once a large number of children of different age, classifying the measurements by age, and assuming that the values obtained are those that would have been obtained had children of the same age been measured yearly throughout their period of growth. The generalizing method deals with units rather than individuals. The children who furnish the measurements for age eight are not the children who furnish the measurements for age nine. They are different for each year. The results, therefore, say nothing as to the growth of the individual child from year to year, except what may be inferred from the increase in the type value. If the boy *X* and the boy *Y*, who at age seven are in the seventy-five and the twenty-five percentile grades respectively, change places at age eight, the central value will be unaffected by the change, for the distribution of units will be the same as before, but the growth-curve of the individual boys will show a large deviation.

This lack of material is especially to be regretted because the rate of growth or annual increase is certainly a more reliable guide than the height and weight at any one year. The lacking material, however, can be easily collected, and those in charge of schools should see to it that measurements of the same children are made annually, or oftener, throughout their school life. In the course of fifteen or twenty years such measurements would solve the crucial problem of the rela-

tion of the individual to the type. Those who reflect upon the questions mentioned in these pages will hardly avoid the conclusion that this gap in the theory of child-growth does not prevent the extended use of anthropometrical measurements in schools.

There are no doubt many opinions as to the way in which such measurements should be employed. As to details, such differences are inevitable, and are to be welcomed rather than regretted. On the other hand, a difference of opinion as to main working lines is to be deprecated, for these lines are the logical outcome of fundamental principles. The working plan of every system grounded on these principles should provide for (1) The annual record of the height and weight of every pupil; and (2) The placing of pupils whose weight to height ratio is above the seventy-five or below the twenty-five percentile grade of their age under special supervision, in order that they may not be overtaxed by the work exacted of the normal child.

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Other articles upon various phases of Child-study have appeared in the *EDUCATIONAL REVIEW*, as follows :

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