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STANDARDS FOR GROWTH AND NUTRITION *

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The widespread interest lately aroused in the prevalence and degree of malnutrition among school children makes it desirable to examine anew the facts of normal growth in this class of our population. The existence of undernourishment or malnutrition presupposes a normal standard which must be reached if a child is to be considered in perfect health.

The standards by which nutrition has been chiefly measured in the past have been the body-weight and the rate of increase in weight as compared with normal averages. Height and rate of growth in height have also been given a certain amount of value. Most observations have considered both height and weight in relation to the age of the child. The purpose of this paper is to show that the weight-to-age and height-to-age relationships are of comparatively little value in estimating the nutrition of the body. The relation of weight to height is the only one which is reliable.

The standards of nutrition which are susceptible of application to large groups of children are three:

1. The weight-to-height relationship.
2. The annual rate of increase in weight and growth in height.
3. The general appearance of the child.

In the first two of these it is easy to determine the *average*; not so easy to decide what is *normal*. Considerable variations from the average may coexist with normal nutrition. It is important to understand and appreciate how wide the individual variations may be among healthy children of the same race and living in the same environment. What deviation from the average is to be regarded as abnormal, is a question about which differences of opinion may readily exist. Any

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standard fixed must be an arbitrary one. To consider as under-nourished any child who falls 10 per cent. or more below the normal average is a workable standard and may be adopted in practice until further experience throws more light on the subject.

Since the pioneer work of Quetelet many observations have been made both in this country and abroad on the weight, height and growth of children of the different ages of different races and environment. A special interest attaches to this subject at present, since it is the prevailing opinion that the nutrition of children in all the belligerent countries has greatly suffered because of war conditions and the rise in the cost of food.

In this article will be considered only children of the usual school ages, 5 to 16, inclusive, not because these are more important, but because more data are available than for children of the pre-school age. In the charts given we have, for similar reasons, included only those relating to boys.

During the first year of life we have been accustomed to regard the weight as the chief or sole measure of the progress in nutrition. A regular gain in weight is universally considered as the best evidence of proper growth (an exception of course being made in the case of infants fed on certain proprietary foods and others on mixtures abnormally high in carbohydrates). The growth of the infant in length has been regarded of interest chiefly for the recognition of such conditions as affect the growth of the long bones—rickets, cretinism, chondrodystrophy, etc. After the first year growth of the body in length becomes of more and more interest and of increasing importance in relation to normal nutrition and growth, but it has not received the attention which it should.

Weight and Age Variations.—By far the largest number of observations on weight published have been of weight in relation to age, and the opinion has gained currency that a child of a certain age should have a certain weight to be normal, a moderate latitude for individual variations being allowed. Since most observers give only the *average* weight of children of the different years, it is somewhat difficult from their figures to estimate for the individual variations.

In Chart 1 are given the actual net weights of boys in the Browning School¹ in New York City. It represents 1,774 observations on about 350 different boys whose weights were taken semi-annually, without clothes, over a period of years, the average number of observations on each boy being five. This group of American boys, with but few

1. I wish to express my thanks to Mr. John S. Browning, headmaster of the school, for the use of these data, and also to Dr. C. M. Williams, physical director, by whom most of the weights and measurements were taken.

Chart 1.—Age and weight. Boys from the Browning School; 1,774 observations on 350 boys.

exceptions, came from wealthy families and had had the advantage of good care and proper food all their lives. How wide the variations are for the different ages is seen from a glance at the chart. Omitting the few very high and the few extremely low weights, we note that the individual variations for the different years are approximately as shown in Table 1.

TABLE 1.—WEIGHT-AGE INDIVIDUAL VARIATIONS (BROWNING BOYS)

At Age	Range, Pounds	Variation, Pounds	Years' Growth, Approximately
11.....	60- 90	30	5
12.....	65-105	40	5
13.....	70-115	45	5
14.....	78-125	47	4
15.....	90-140	50	3½

These extreme variations in healthy boys of the same social class show how hard it is to fix on a standard weight for any age. In this series slightly more than one-fourth the boys were more than 10 per cent. below the average weight of the group for the age.

It is interesting to compare these figures with those of Bowditch² for Boston public school boys of corresponding ages. Omitting here also the few extremely high and extremely low weights we have the results set forth in Table 2.

TABLE 2.—WEIGHT-AGE INDIVIDUAL VARIATIONS (BOWDITCH BOYS)

At Age	Range, Pounds	Variation, Pounds	Years' Growth, Approximately
5.....	32- 52	20	5
6.....	36- 56	20	4
7.....	40- 60	20	4
8.....	44- 64	20	4
9.....	48- 72	24	4
10.....	52- 76	24	4
11.....	56- 84	28	5
12.....	60- 96	36	4½
13.....	64-108	44	5
14.....	68-116	48	4
15.....	84-128	44	3½
16.....	96-142	46	3

His observations average about 350 for each year of age. Nearly one-fourth of these boys (23.2 per cent.) were 9.3 per cent. below the average weight for the age, while one-tenth of his boys were 17.2 per cent. below the average weight of the group for the age.

When we come to compare the observations³ upon weight and age

2. Bowditch: Growth of Children, Public Document, Massachusetts State Board of Health, 1877.

3. The data from which the curves in this paper have been constructed are taken from U. S. Bureau of Education, Bulletin 10, 1914, by Bird T. Baldwin. In this will be found a very extensive bibliography on the growth of school-children.

Chart 2.—Weight and age. American boys.

	Approx. No. Observations
A. Boas, California	1,900
B. West, Worcester, Mass.	1,500
C. Peckham, Milwaukee	4,000
D. Barnes, Oakland, Calif.	2,500
E. McDonald, Washington, D. C.	7,000
F. Bowditch, Boston, Mass.	13,000
G. Baldwin, Chicago and New York ..	100
H. Smedley, Chicago	2,500
J. Hastings, Nebraska	7,000
K. Felter, St. Louis	16,000

made in different parts of the United States and those made in foreign countries with the foregoing we see how wide the average weight-age variations are.

In Chart 2 are given the average weight curves of ten different series of observations on American schoolboys made in widely scattered parts of the country. These represent in all nearly 50,000 observations. The lowest average curves are "J," that of Hastings, and "K," of Porter; the highest average is "A," that of Boas. The solid black line, "F," of Bowditch, is very nearly the mean of the entire group, and may therefore perhaps be taken, as well as any single curve can, as the average curve of the country as a whole.

It will be noted that the variation in these curves, which represent averages, at 6, 7 and 8 years is only about 5 pounds; also that this variation steadily increases with the age, so that at 14 and 15 years it is about 15 pounds. There is, however, a general parallelism to the curves, indicating that the rate of gain is nearly the same in the different groups.

When Chart 2 is compared with Chart 3 it is evident what a large part nationality plays in modifying a weight-age curve. The observations in Chart 3, like the others, were made on boys in public schools. The heaviest boys for their ages are Russians and Polish (A and B). The lightest are Japanese (H); then in order come the Italian in Italy (G); Italian in the United States (K), and the German (J). Even omitting the Japanese, we see how wide is the variation in the weight-age curve among the European nations, all of which are represented in our present American population. With such wide variations as those noted both in foreign and in American boys it is evident that weight for age is not of great importance in determining the nutrition of a child.

Height and Age Variations.—The curves for height and age in a general way correspond to those of weight and age among the different groups in the United States and also among the foreign boys in their relation to each other, but the variations in the height-age curves are considerably narrower.

Chart 4 shows the variations in a group of boys of the same nationality and the same social environment—the boys of the Browning School. Omitting the few extremely high and extremely low measurements we note in Tables 3 and 4 the range and variation in height.

Both these groups show how wide are the individual variations met with in boys of the same general class. By comparing these tables with the weight-age Tables 1 and 2, it will be seen that, estimating in years' growth, the differences in weight among individuals are less

Chart 3.—Weight and age. Foreign boys.

	Approx. No. Observations
A. Erismann, Russian	2,450
B. Suligowski, Polish	1,250
C. Stevenson, British	25,000
D. Roberts, British	17,000
E. Hertel, Danish	14,000
F. Key, Swedish	900
G. Pagiani, Italian in Italy	9,000
H. Misawa, Japanese	4,700
I. Schmidt, German	.....
J. K. Hrdlicka, Italian in U. S.	.....
K.	.....

than the differences in height, and that in both weight and height as boys approach maturity these differences tend to become less.

In Chart 5 are given the height-age curves of the American boys whose weights are given in Chart 2. It will be seen how closely these curves of average height of different groups correspond.

Only one, "A," Baldwin's, differs in any important degree from the average; "K," Porter's curve, is a little lower than the others; and "B," West's curve, a little above. The curves of the other seven observers are almost identical. The solid black line, "D," is the curve of Bowditch. This line may therefore be taken as a fair average of school boys of the United States.

TABLE 3.—HEIGHT-AGE INDIVIDUAL VARIATIONS (BROWNING BOYS)

At Age	Range, Inches	Variation, Inches	Years' Growth, Approximately
11.....	53-60	7	3
12.....	55-62	7	3
13.....	58-64	8	2½
14.....	59-67	9	2½
15.....	61-70	9	2
16.....	62-72	8	2

TABLE 4.—HEIGHT-AGE INDIVIDUAL VARIATIONS (BOWDITCH BOYS)

At Age	Range, Inches	Variation, Inches	Years' Growth, Approximately
5.....	38-44	6	3
6.....	40-46	6	3
7.....	42-49	7	2½
8.....	44-51	7	2½
9.....	46-53	7	2½
10.....	48-55	7	2½
11.....	49-57	8	2½
12.....	50-60	10	3
13.....	52-62	10	3
14.....	54-65	11	3
15.....	57-67	10	2½
16.....	60-70	10	2½

In Chart 6 are given the curves showing average heights at the different ages of various foreign groups of boys. The variations are almost as great as are seen in the average weights of these boys, and in a general way the curves of weight and height correspond. It is clear, then, that in height as well as in weight, race must be taken into account in determining the normal average.

When very large groups are considered, the increase in height and in weight goes on together proportionately in children who are perfectly healthy. When smaller groups or individuals are closely observed it is seen that growth in height is, with the majority, more irregular than the increase in weight and is influenced by many conditions about which as yet we know very little. In private practice

Chart 4.—Age and height. Boys from the Browning School; 1,758 observations on 350 boys.

one is constantly impressed with the great influence of heredity as affecting growth in height. This is a factor the importance of which it is difficult to estimate when large numbers of school children are measured. The variations in height are so great that it is difficult to say how wide a deviation from the average may be considered abnormal even in the same race and social status. In the young the impulse to grow is so strong that even when food is insufficient it may continue, the increase in height taking place at the expense of the stored-up materials in the body. It may be coincident with no increase in weight or even at times with actual loss in weight. As a guide to a child's nutrition, height-age curves are therefore quite unreliable.

Weight-to-Height Variations.—A much more important relationship than weight-to-age or height-to-age as an indication of the state of the child's nutrition is that of the weight-to-height. The value of this is recognized by all the insurance companies. What an adult man or woman should weigh for his or her height is brought to our notice constantly by the figures given on the penny-in-the slot scales. In childhood less attention has been paid to this relationship than its importance deserves, and even though here there are no absolute figures of weight-to-height which can be regarded as normal, and there are considerable individual variations seen in healthy subjects, yet these variations from the average are not so great but that they furnish important information regarding the nutrition of the child.

Considering how wide is the variation seen in different races in the height and weight of boys of the same age, it is rather surprising to see how nearly alike are the curves of weight-to-height. This is shown in Chart 7, which gives the weight-to-height curves for boys from five different nationalities; the two tall and heaviest (Russian and Polish), the two small and lightest (Italian and Japanese) and the American, using Bowditch's figures for Boston school boys of American parentage.

That these curves are so nearly alike indicates how independent of nationality is this index of nutrition. Thus, the average Japanese boy of 50, 60 and 80 pounds is only one inch shorter than the average American boy of the same weight; while those of 70 pounds weight appear exactly the same height. So, also, the Italian boy, who, though much shorter than the American for his age (Chart 5), is for his weight only from half an inch to an inch shorter than the American up to a weight of 105 pounds and a height of 62 inches; the only exception to this being the short period when the weight is in the neighborhood of 50 pounds and the height near 50 inches. The chief difference between the tall and short races is that in the latter growth is slower and ceases at an earlier period.

Chart 5.—Height and age. American boys.

	Approx. No. Observations
A. Baldwin, Chicago	300
B. West, Worcester, Mass.	1,500
C. Peckham, Milwaukee	4,000
D. Bowditch, Boston	13,000
E. Boas, California	44,000
F. Smedley, Chicago	2,500
G. Barnes, Oakland, Calif.	2,500
H. Hastings, Nebraska	7,000
J. McDonald, Washington, D. C.	7,000
K. Porter, St. Louis	15,000

Weight-Height Index.—The determination of where a child stands in the relation of his height to his weight is undoubtedly the best simple guide in fixing his status as to his nutrition. This ratio expresses the general solidity or robustness of the body and is therefore significant. The weight in kilos divided by the height in centimeters, or weight in pounds divided by height in inches gives what is sometimes called the *weight-height coefficient* or *weight-height index* of the individual. This weight-height index increases steadily and quite uniformly from $5\frac{1}{2}$ up to 18 years. According to the observations of Baldwin, the lowest weight-height index in boys is at 6 years, when it is 0.15; the highest is at $17\frac{1}{2}$, when it is 0.40.

The same thing is shown in another way in Table 5, the data for which are taken from Bowditch. Here is given the increase in weight which corresponds to each inch increase in height.

TABLE 5.—WEIGHT-TO-HEIGHT INCREASE

Boys				Girls		
Height, Inches	Weight, Pounds	Increase Per Inch, Pounds	Approx. Age, Years	Weight, Pounds	Increase Per Inch, Pounds	Approx. Age, Years
42	41.8	...	5	40.9	...	5
43	43.6	1.8	..	42.6	1.7	..
44	45.6	2.0	..	44.5	1.9	..
45	47.6	2.0	6	46.5	2.0	6
46	49.6	2.0	..	48.5	2.0	..
47	52.1	2.5	7	50.7	2.2	7
48	54.6	2.5	..	53.2	2.5	..
49	57.3	2.7	9	56.1	2.9	9
50	60.2	2.9	..	58.8	2.7	..
51	63.2	3.0	10	61.4	2.6	10
52	66.3	3.1	..	64.4	3.0	..
53	69.2	2.9	11	67.5	3.1	11
54	72.7	3.5	..	71.0	3.5	..
55	76.4	3.7	..	74.9	3.9	..
56	80.2	3.8	12	78.8	3.9	12
57	84.0	3.8	..	83.4	4.6	..
58	87.9	3.9	13	87.9	4.5	..
59	91.6	3.7	..	93.3	5.4	13
60	95.5	3.9	..	98.8	5.5	..
61	100.5	5.0	14	105.4	6.6	..
62	105.6	5.1	..	115.7	10.3	14
63	110.7	5.1	15	.....	.....	..
64	115.9	5.2	..	.....	.....	..
65	121.0	5.1	16	.....	.....	..
66	126.6	5.6	..	.....	.....	..
67	136.1	9.5	..	.....	.....	..

In all observations on weight and height of children the *average* is not to be confused with or regarded as the *normal*. There are considerable variations on either side of the average which should be regarded as within the range of the normal. The normal is a zone, not a line. How far below the average weight for his height a child should be for his nutrition to be considered below the normal, one cannot say

Chart 6.—Height and age. Foreign boys.

	Approx. No. Observations	Approx. No. Observations	
A. Hertel, Danish	17,000	F. Suligowski, Polish	1,000
B. Stevenson, British	.....	G. Pagliani, Italian in Italy	900
C. Roberts, British	25,000	H. Schmidt, German	4,700
D. Key, Swedish	14,000	J. Misawa, Japanese	9,000
E. Erlmann, Russian	3,000	K. Hrdlicka, Italian in U. S.	.....

absolutely. If we regard all those who are 10 per cent. or more below the average line as undernourished or as examples of malnutrition, we shall not go far wrong. For practical purposes we may assume this to be correct.

Annual Rate of Increase in Weight and Height.—The weight to height relation we have concluded to be the best general starting point or base line for observations on the nutrition of children;⁴ but nothing indicates their progress so well as the annual increase in height and weight. Like an infant, a boy or girl to be healthy must grow; and a record of such growth of any child extending over a period of years will be found to be an accurate and trustworthy record of his general health during that period.

The annual rate of gain of healthy school boys of corresponding ages is nearly the same in different parts of the United States and in foreign countries. In the accompanying table (6) is given the average annual gain in weight and height of American boys and girls, calculated from the data represented in the curves previously given. It will be noted that in the boys the gain in weight increases with each year of age after 7 years, except between 10 and 11, when it is less than for the preceding period. This slowing up in growth before the marked increase of approaching puberty is noted in nearly all the different groups of boys observed.

The yearly increment in height is less between the tenth and twelfth years than before or after this period. Like the increase in weight, it is least between 10 and 11 years. It does not show a marked increase until after 12, when the rapid growth of puberty begins. This is about a year later than the more rapid increase in weight.

As children grow older the increase in height and weight is less uniform and regular. There are seen with nearly all healthy children periods, often of several months' duration, in which growth and gain in weight are rapid, followed by periods in which both are much slower. This may occur where no special cause can be discovered. It is often seen as puberty approaches.

Children who are much below normal weight usually gain rapidly when the cause for the low weight can be discovered and removed.

Seasonal Growth.—The question is often discussed during what season of the year the most rapid growth in height and increase in weight occur. The observations made on the Browning boys are of interest as throwing some light on this point. Of 703 observations

4. There are some exceptions to this rule. Certain children, not a large group, may be stunted in growth by conditions which also affect weight, so that the relation of weight to height is average, though the child is much below the normal in both.

Chart 7.—Weight and height.

made on weight for the six months from November to May and from May to November, the average gain for the summer six months was $1\frac{1}{4}$ pounds greater than for the same boys during the winter six months. The same thing was seen in growth in height. Of 544 observations made on height, the average increase was 0.36 inch greater for the summer six months than for the same boys during the winter six months. These facts confirm the general law that in healthy individuals increase in weight and growth in height go on together and approximately at the same rate.

TABLE 6.—AVERAGE ANNUAL INCREASE IN WEIGHT AND HEIGHT
AT THE DIFFERENT AGES
BOYS

Age, Years	Weight		Height	
	Range, Pounds	Average, Pounds	Range, Inches	Average, Inches
6-7	3 - 5	4	1.5-2.5	2
7-8	3.5- 5	4.75	1.5-2.5	2
8-9	4 - 6	5.25	1.5-2.5	2
9-10	4 - 7	6	1.5-2.5	2
10-11	4 - 6.5	5	1.4-2.0	1.7
11-12	4.5- 7.5	6.5	1.3-2.0	1.8
12-13	6 - 9	8	1.5-2.5	2
13-14	8 -12	10	2 -3	2.5
14-15	10 -15	12.5	2 -3.5	2.7
15-16	9 -15	13.75	2 -3.5	2.7
16-17	4 -12	6.5	0.5-2	1.2
17-18	4 - 8	5	0 -1	0.5

GIRLS

Age, Years	Weight		Height	
	Range, Pounds	Average, Pounds	Range, Inches	Average, Inches
6-7	3 - 5	4	1.5-2.5	2
7-8	2 - 5	4.5	1.5-2.5	2
8-9	3.5- 6	5	1.3-2.4	1.75
9-10	4 - 6	5.25	1.5-2.5	2.25
10-11	4.5- 7	6.5	1.5-2.5	2
11-12	7 -11	9.5	2 -3	2.5
12-13	8 -12	10.5	2 -3	2
13-14	7 -11	9.5	1.3-2.4	2
14-15	5 -10	7.5	1 -2	1.25
15-16	3 - 8	6	0 -1	0.75
16-17	2 - 6	3.5	0 -0.5	0.50
17-18	0 - 2	0.5	0 -0.2	0.2

The explanation for more rapid growth during the summer season would seem to be that this period includes the school boy's vacation time, during which he leads a more free and more outdoor life; while the winter period includes most of the colds and other respiratory diseases and a large part of the contagious diseases from which those of these ages are likely to suffer, all of which arrest growth and gain in weight.

General Appearance.—In estimating a child's condition as to his nutrition, careful inspection may tell a good deal, particularly to an experienced observer. The color of lips and cheeks and the facial expression are significant of anemia, fatigue or even exhaustion. If the clothing is removed to the waist, the muscular development and the amount of subcutaneous fat can be determined as well as a narrow chest and round shoulders recognized. Such an inspection taken in connection with height and weight enables the examiner to form a pretty accurate estimate of the child's nutrition.

The so-called Dunfermline scale in which children are graded in their nutrition by their appearance as I, good; II, fair; III, below average; IV, very bad, is not a very trustworthy way of estimating the nutrition if such inspection is made without undressing the child at all and without taking account of height and weight. But taken in conjunction with height and weight and when made by a person of experience, the general appearance is of great assistance in grading the child, and the grouping in the above scale is very convenient for practical purposes.

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