

# SIZE AND WEIGHT IN ONE HUNDRED AND THIRTY-SIX BOARDING SCHOOL BOYS (GROTON) \*

H. GRAY, M.D. AND W. J. JACOMB

BOSTON, MASS.

GROTON, MASS.

## PART I

*How Many Children are Unfit.*—The necessity for further study of this seemingly hackneyed topic is clear from the statement of Emerson <sup>1</sup> that his extended studies have shown that at least one-third of the children in this country are sufficiently underweight for their height to require treatment for malnutrition. In another place, also in 1919, he re-affirmed that from 20 to 40 per cent. of those graduating from elementary schools are physically unfit. By way of definition of the unfit, he urged that "all children habitually 7 per cent. or more underweight for their height are not only undernourished but malnourished, retarded in both weight and height from one to four years."

L. B. Gloyne (1920) has reported similar disquieting findings in school children.

It occurred to us to compare the weights (and also the height and chest-girth) of a series of private school boys with the usual standards. In brief, our findings were that the boys' weights as provided by these standards averaged more than 7 per cent. above their weights as actually observed.

Hence, either one of two things may be true: (1) These children of good American parentage, liberal feeding, expensive education, extensive outdoor life, and careful medical supervision, were none the less abnormal, or in Emerson's words, "physically unfit"; or (2) the current standards are "unfit" for judging this "cultured type" of boy.

*Lack of a Standard Suitable for Private School Boys.*—That the latter is the case is indicated by the large number of current standards. Indeed, their number and divergent nature indicates that no one of them has won general approval, even for judging boyhood in general in American public schools.

The purpose of this paper is to compare certain of these standards with the actual observations on 136 healthy private school boys in order to determine which of these standards is the most suitable for use in connection with this particular class.

---

\* Received for publication April 11, 1921.

1. Emerson, W. R. P.: Boston M. & S. J. **181**:139 (July 31) 1919; International Clin., Series 29, **4**:212, 1919; Am. J. Dis. Child. **17**:251 (March) 1919.

For one thing, it seems worth while to differentiate the normal from the ideal. The usual standards of normal have been compiled by making observations on public school boys of widely differing heritage. In other words, the subjects studied have been in many cases children who have not had the advantages of the best environment and nourishment, and who also come from parents of short stature.

It has been pointed out by Friedenthal (1914), and Holt,<sup>2</sup> (1918) and particularly exhaustively by Benedict and Talbot,<sup>3</sup> (1921) in their report to the Carnegie Institution, that the usual standards mentioned above are not suitable for children who spring from at least several generations of American stock, which is admittedly taller than that of many foreign nations, to which belong the parents of many of our public school boys; children who, besides, have been nurtured in as nearly an ideal manner as possible today.

It seems justifiable, therefore, when one is desirous of estimating the normality of a boy in a boarding school or in a country day school, to use as a standard figures compiled from similar boys, instead of the usual figures compiled from the variegated population of a public school. Such a standard may be called an ideal standard to differentiate it from the usual normal. Such standards are presented herewith in brief, and will be more fully presented elsewhere.

#### MATERIAL

The subjects studied were 136 boys at Groton School, Groton, Mass., a private boarding school in the country, about two miles from the nearest town. Boys who were not perfectly normal on physical examination were not included in this study. This sifting and exclusion of the subnormal is essential, since Emerson, in 1917, in a vital group study of the results of one-hundred physical and mental examinations of so-called well children, aged from 5 to 15 years, demonstrated that 98 per cent. of these children had from one to eleven abnormal conditions, with a total of 472 conditions actually needing treatment. Recently, he has enlarged his series to 602 children with much the same extraordinary results.

The subjects here reported on seemed to be not only physically unexceptionable, but were also carefully protected from the most frequent factors enumerated by Emerson<sup>1</sup> (1919) as causing malnutrition, namely: (1) Physical defects, such as adenoids and abnormal tonsils and carious teeth; (2) faulty health habits, such as (a) the use of tea and coffee; (b) the absence of milk and cereals from the diet; (c) fast eating and irregular meals; (d) the use of sweets between

2. Holt, L. E.: *Tr. Am. Pediat. Soc., Arch. Pediat.* **35**:339 (June) 1918.

3. Benedict, F. G., and Talbot, F. B.: *Metabolism and Growth*, Publication 302 Carnegie Institution, Washington, 1921, p. 33.

meals (school located a long distance from the temptation of stores, and relatives urged not to send candy to the boys), (e) sleeping with closed windows (dormitories, thus preventing individual window closing from interference), (f) overfatigue, (g) over-pressure and too long periods of work, (h) too little time in the open air; (i) irregular living due to lack of control, and (j) late hours.

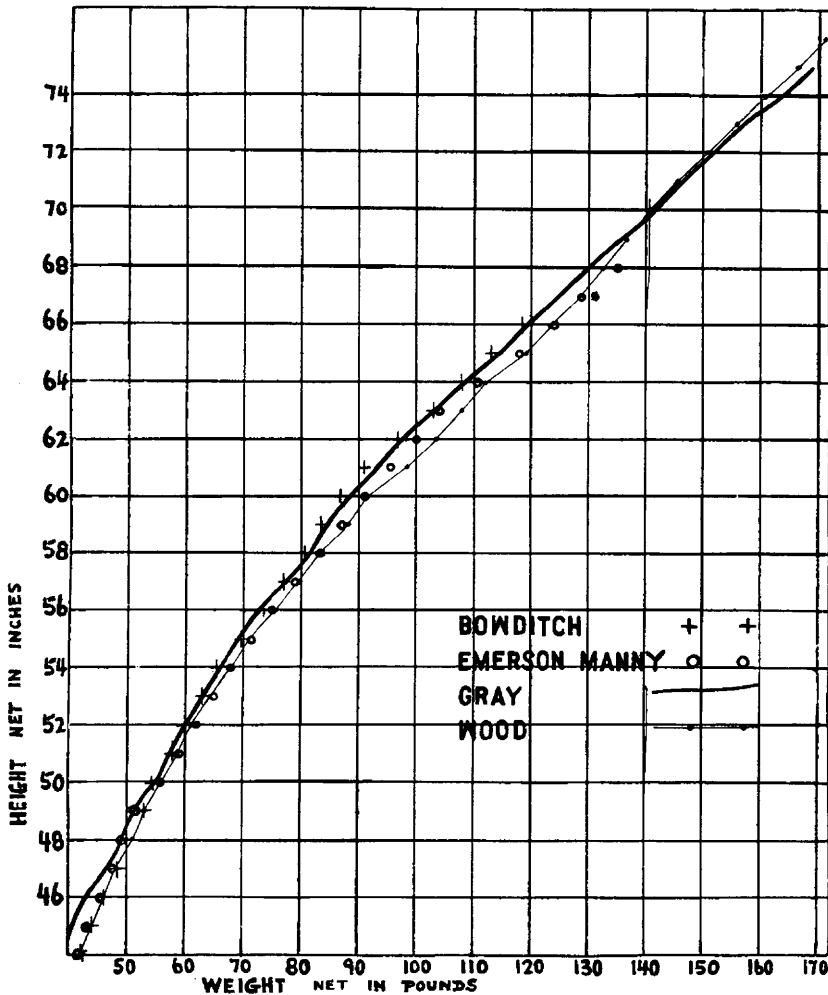


Chart 1.—Weight for height, according to different observers.

#### MEASUREMENTS

*Observer.*—The observations were made by (or under the immediate supervision of) one of us (W. J. J.), who is in constant daily attendance as full time physical director at the school.

*Age.*—To nearest, not last, birthday.

*Height.*—To nearest quarter-inch, at least. It would have been preferable to use the metric system, but this was not done out of regard for the persistence in pediatric work of the traditional English units. All measurements of height, as well as of chest-girth and weight, were made without clothes. The height should not be measured with the movable rod attached to the upright of scales, because (1) the subject is generally unable to straighten up the heels, hips, shoulders and head properly against a single rod, and (2) the small but still avoidable error due to the flexibility of the horizontal bar. Height should be measured with the subject straightened up against a wall or door.

*Chest Girth.*—This measurement represents the mean of the measurements taken at full inspiration and full expiration, at the level of the nipple and the angles of the scapulae; arms hanging relaxed.

*Weight for Height, not for Age.*—In utilizing most of the tables, it single observation is worthless, since a pound difference is easily produced by exercise or by drinking two glasses of water or eating an ordinary meal.

#### METHOD OF TESTING STANDARDS

This simple procedure has been described fully in a previous paper on adults.<sup>4</sup> In brief, the difference between the actual weight of each person and the weight as predicted for him by the method being tested, was first noted in pounds, then translated to a percentage of the actual weight. This percentage is clearly necessary, since, for example, fourteen pounds divergence from the weight of a person weighing 200 pounds is only 7 per cent., whereas in a child weighing 100 pounds, the prediction error is serious, namely, 14 per cent.

Then, these percentage deviations from the 136 calculated weights were summed and averaged, yielding the mean percentage error for the particular method (weight table or formula) under consideration.

#### STANDARDS STUDIED

*Weight.*—Stripped, to the nearest pound. Greater accuracy in a is important to appreciate that the present day view has supported and developed the cursory suggestion of Bowditch, that age is of practical

4. Gray, H., and Gray, K. M.: Normal Weight, Boston M. & S. J. **177**:894 (Dec. 27) 1917. Gray, H., and Allen, F. B.: Weight in Soldiers, J. A. M. A. **74**:1732 (July 19) 1920. Gray, H. and Allen, F. B.: Bornhardt's Formula, Boston M. & S. J. **184**:334 (March 31) 1921. Gray, H., and Mayall, J. F.: Body Weight in 229 Adults, Which Standard Is the Best? Arch. Int. Med. **26**:133 (Aug.) 1920. (This discusses other references.) Gray, H., and Root, H. F.: Stem-length and Trunk-length, Boston M. & S. J. **184**:439 (April 28) 1921. Weight Prediction by the Formulae of Bornhardt, of Von Pirquet, and of Dreyer, Boston M. & S. J. **185**:28 (July 7) 1921.

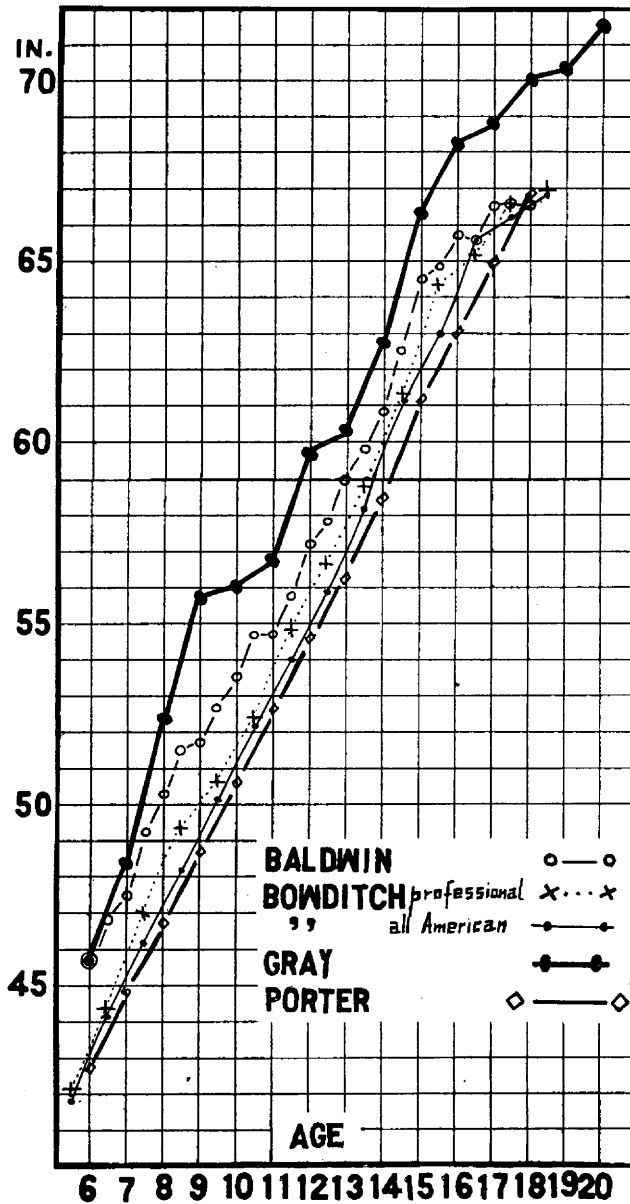


Chart 2.—Height for age.

importance only in predicting growth in height. Then, when it comes to predicting weight, or the state of nutrition, in the words of Von Pirquet (1913) "we have to compare the actual weight not with the average weight for age, but with the actual height." The same view

is held among others, by Holt (1918), Dufestel (1920), and Benedict<sup>5</sup> (1919), who summarizes the situation concisely:

If the height is too small for the age, one may logically assume either that the child is the offspring of a family of normally short stature or one may suspect deficiency in the skeletal growth. On the other hand, a child may be of the normal or average height for the age and yet be definitely under weight.

While his oft-quoted original tables showed weight for age, Bowditch also calculated indirectly the weight for height. The latter table seems to have been neglected till reproduced by Holt.<sup>6</sup> The labor of testing this standard has been omitted, as the curve runs so close to the curve of Wood, which is more recent and is based on an even larger number of children. For the same reason no tests were made with certain other tables cited below.

In 1910, Wood published a table based on boys at the Horace Mann School. Later he found that this original table in the Ninth Year Book was based on too small a number of observations so that there was too much irregularity in these tables, and for the older and especially the taller children the weights were not high enough to be typical for the median values. These original tables were based on the mode and that seemed to Wood the most scientific, accurate basis if one has a large enough number of observations.<sup>7</sup>

In 1920 he gave a revised table for weights of children, of which he remarked:

While the revised tables are based upon a number of different sources, they are made up, of course, on actual observations. I wish that we might have the tabulation of about one million boys and girls for each of three types of physique. This would give to us a very interesting basis for comparison with the tables which have been prepared. It does seem likely that we shall have such a colossal piece of work done in the near future.

The different sources which he used included at least 250,000 of each sex, and were as follows: (1) Statistics of American school children published by Baldwin,<sup>8</sup> Boas, Bowditch, Hastings, Holt, Porter<sup>9</sup> and others. (2) Statistics from about 10,000 records of children in the Horace Mann School, collected during the past eighteen years. (3) Statistics of life insurance companies for periods of fifteen years and upward. (4) Dublin's statistics of children from 14 to 16 years of age examined in New York State for the issuance of working papers.

5. Benedict, F. G.: Boston M. & S. J. **181**:107 (July 31) 1919 Benedict, F. G., and Hendry, M. F.: Boston M. & S. J. **184**:262 (March 17) 1921.

6. Holt: Diseases of Infancy and Childhood, Ed. 8, D. Appleton & Co., New York, 1919.

7. Wood, T. D.: Personal Communications, March 30, April 7, 1920.

8. Baldwin, B. T.: Physical Growth and School Progress, Bull. No. 10, Whole No. 581, U. S. Bureau Educ., Washington, 1914, p. 189.

9. Porter, W. T.: Quart. Publ. Am. Statistical Assn. **3**:576 (Dec.) 1893. Am. J. Physiol. **52**:121 (May) 1920.

This table was reprinted on a 4 x 5-inch card, by the Division of School Hygiene, Bureau of Education, Department of the Interior, Washington, D. C., and may be obtained by writing there. It was also reprinted in an interesting pamphlet<sup>10</sup> published by the Child Health Organization of America, 156 Fifth Avenue, New York City.

It is particularly to be noted that Wood's 1910 table gave net weights and heights, whereas his 1920 table gave net heights but weights with average indoor clothing.

With reference to the weight of the clothing, he considered that with the present fashions the clothing with the shoes removed, and in the case of boys with the jacket also removed, may be estimated on the

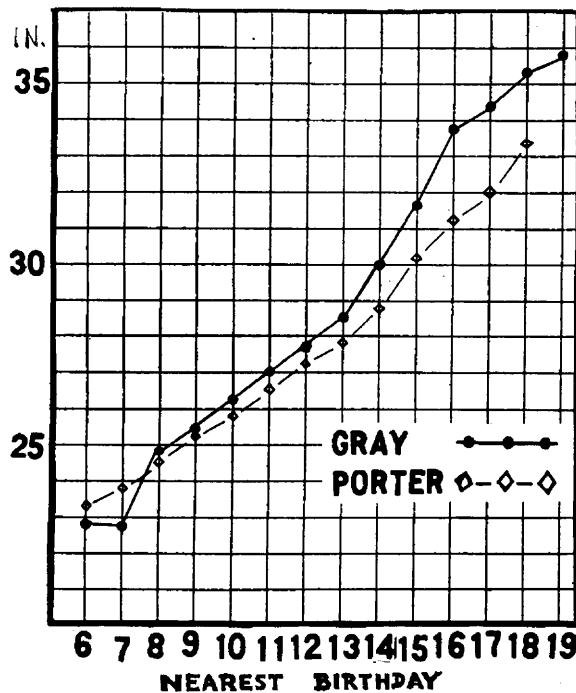


Chart 3.—Chest for age.

average of three pounds for girls, and four pounds for boys. If the child be measured in shoes, Wood recommended subtracting one inch from the height to get the net height for use with the table.

As the present subjects were measured stripped, it was necessary to adjust Wood's 1920 table (we have not used his 1910 table) by allowing for clothes. This was done in two ways: (a) by subtracting throughout four pounds as he suggested, and (b) by subtracting at different ages the corresponding varying weights of clothes as estimated

10. Holt, L. E.: 1920 Standards of Nutrition and Growth.

by Bowditch in 1877. The importance of the clothing is indicated by the divergent results: the average prediction error with method (a) was 8.27 per cent., and with method (b) only 7.17 per cent.

The Emerson and Manny tables<sup>11</sup> (1920) were for the early years derived from the figures given in Holt's book, that is to say, Bowditch's figures; and for school age obtained by "setting forward" by six months the "basal studies of Boas and Burk which incorporated the work of Bowditch, Peckham, Porter, Smedley, and others, aggregating in all some 90,000 measurements."

Retan<sup>12</sup> gave a table with shoes and clothes, and made the interesting statement that "in using the relation of height to weight as a standard, I have found that it is not necessary to remove shoes. The loss in height from the removal of the shoes compensates for the loss in weight from the shoes." His Chart 4 supports this view. Another interesting contention by him is supported by his Chart 5, plotted from the scale of Boas and Burk, "which tends to prove that a separate scale of measurements is not necessary for each sex." Like Holt, Retan says: "It is obvious that nationality plays no rôle in the measure of nutrition when the nutritional standard is represented by zones based on the relation of weight to height."

TABLE 1.—SIZE STANDARD FOR PRIVATE SCHOOL BOYS  
(Referred to Age at Nearest Birthday. Based on Averages from 380 Boarding  
and County Day School Boys After Exclusion of Those Subnormal  
on Physical Examination)

Age Nearest Birthday	Height Net in Inches	Chest-Girth Mean Net in Inches	Number of Boys	Age Nearest Birthday	Height Net in Inches	Chest-Girth Mean Net in Inches	Number of Boys
6	45.7	22.9	3	14	62.8	30.0	42
7	48.1	22.8	6	15	66.2	31.7	69
8	52.1	24.8	16	16	68.2	33.7	54
9	55.8	25.3	19	17	68.8	34.3	47
10	56.0	26.2	16	18	70.0	35.2	29
11	56.8	27.0	19	19	70.1	35.8	14
12	59.7	27.6	15	20	(71.5)	(40.5)	(1)
13	60.1	28.5	30				

*Some New Ideal Tables.*—Independently of, but in agreement with Talbot's opinion as to the need for a new table of weight for height for boys of approximately ideal heredity and environment, one of us has collected data on 380 such persons. The material is small, but being larger than others have reported in the past, it is thought worth reporting as tentative "ideal tables." These are given herewith in Tables 1, 2 and 3 and Charts 1, 2 and 3, and will be more extensively discussed elsewhere. They permit the judgment not only of nutrition (weight), but also of development in size or bony frame (height and chest girth).

11. Emerson, W. R. P., and Manny, F. A.: Arch. Pediat. **37**:468 (Aug.) 1920.

12. Retan, G. M.: New York State J. M. **19**:397 (Nov.) 1919. Arch. Pediat. **37**:32 (Jan.) 1920.



Chart 1 shows that the tentative ideal weights for height run extraordinarily close to Bowditch's sons of professional men, but somewhat lower (higher as plotted on the chart) than the figures of Wood (after subtracting 4 pounds for clothes), and also lower than the values of Emerson and Manny (again after correcting to net values by subtracting 4 pounds).

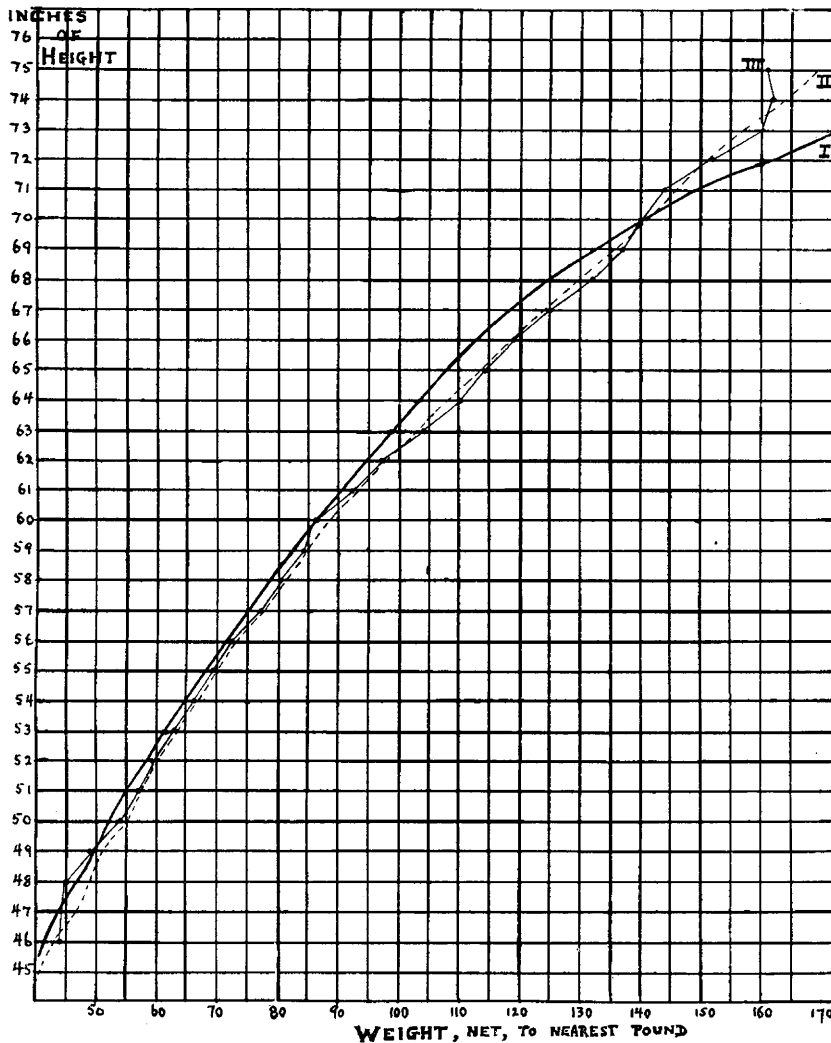


Chart 4.—Weight for height, according to different methods of consolidating 380 ideal observations.

To obtain a control on the accuracy of the ideal height by age table studied in this paper, we examined Chart 5 of Holt's 1919 article on standards for growth. We selected the curve most similar to our own,

namely; the highest height for age, that based on Baldwin's 300 cases. The other nine curves there illustrated were not thought worth experimenting with in the present connection, since presumably the error (generally with Baldwin's table on the low side of fact) would be even worse with these other tables.

TABLE 2.—WEIGHT STANDARD FOR PRIVATE SCHOOL BOYS  
(Referred to Nearest Half-Inch of Height. Based on Averages from 380  
Boarding and Country Day School Boys After Exclusion of  
Those Substandard to Physical Examination)

Height Net to Nearest Half-Inch	Weight Net to Nearest Pound	Number of Boys	Height Net to Nearest Half-Inch	Weight Net to Nearest Pound	Number of Boys
44.5	40	1	60.	86	11
45.	40	0	60.5	89	5
45.5	42	0	61.	92	11
46.	44	2	61.5	95	6
46.5	44	0	62.	97	12
47.	45	1	62.5	101	4
47.5	45	0	63.	104	6
48.	45	3	63.5	107	4
48.5	47	1	64.	110	9
49.	49	2	64.5	112	2
49.5	52	0	65.	114	18
50.	54	4	65.5	117	13
50.5	56	0	66.	119	15
51.	57	1	66.5	122	11
51.5	58	0	67.	125	11
52.	59	5	67.5	129	14
52.5	61	1	68.	132	16
53.	63	10	68.5	135	11
53.5	65	4	69.	137	16
54.	66	6	69.5	139	12
54.5	68	4	70.	140	12
55.	69	3	70.5	142	14
55.5	71	6	71.	144	15
56.	72	11	71.5	148	8
56.5	75	2	72.	152	7
57.	77	7	72.5	156	4
57.5	79	5	73.	160	3
58.	80	9	73.5	161	2
58.5	82	3	74.	162	1
59.	84	9	74.5	162	2
59.5	85	3	75.	161	1

TABLE 3.—WEIGHT STANDARD FOR PRIVATE SCHOOL BOYS  
(Referred to Nearest Half-Inch Chest Girth. Based on Averages from 380  
Boarding and Country Day School Boys After Exclusion of  
Those Substandard to Physical Examination)

Chest-Girth Net to Nearest Half Inch	Weight Net to Nearest Pound	No. of Boys	Chest-Girth Net to Nearest Half Inch	Weight Net to Nearest Pound	No. of Boys
21.5	37	1	31.5	116	14
22.	40	0	32.	120	13
22.5	43	3	32.5	123	14
23.	47	4	33.	127	19
23.5	51	1	33.5	130	16
24.	54	13	34.	134	13
24.5	58	3	34.5	138	24
25.	62	11	35.	141	22
25.5	66	8	35.5	145	9
26.	70	12	36.	149	18
26.5	74	7	36.5	153	7
27.	78	16	37.	157	7
27.5	82	16	37.5	161	5
28.	86	11	38.	165	1
28.5	90	17	38.5	170	1
29.	94	13	39.	176	1
29.5	98	15	39.5	181	0
30.	103	14	40.	187	1
30.5	107	16	40.5	192	1
31.	112	13			

Chart 2 shows that even Baldwin's boys exhibited at each age a considerably smaller stature than the tentative ideal table; that Bowditch's sons of American professional men were even smaller, though distinctly taller than his all-American boys (usually cited); and finally that Porter's subjects (the lowest curve in Holt's Chart 5) lie vastly below our tentative ideal.

As a control, representing the current standard for chest girth (in relation to age), the best without doubt is the table published by Porter in his well-known (1893) monograph,<sup>9</sup> and quoted by Holt in his book.

Chart 3 shows that his subjects at all ages, except 6 and 7, had smaller chest circumferences than the boys represented by the tentative ideal table.

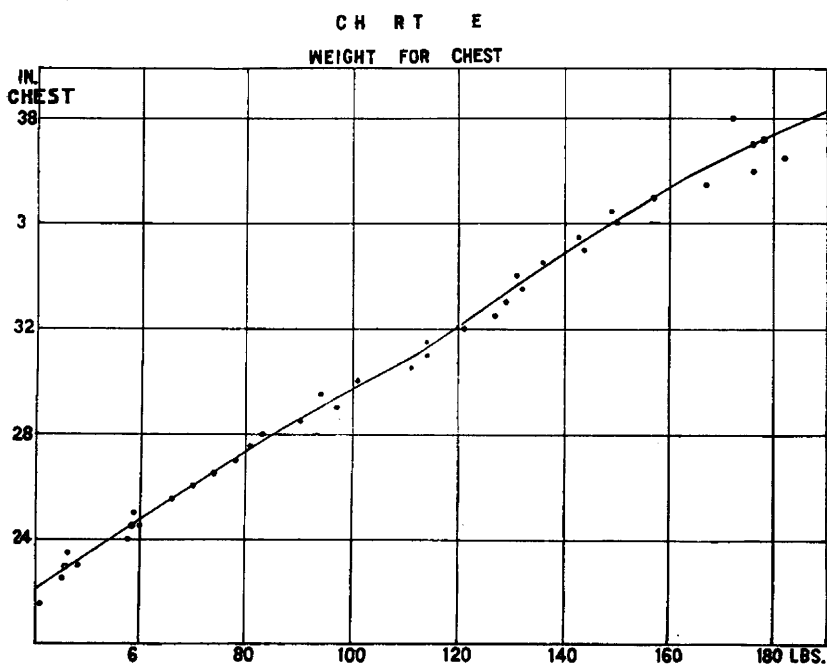


Chart 5.—Weight for chest girth.

#### RESULTS REGARDING HEIGHT

The relative divergence from fact on the part of the height-for-age as predicted by the two standards was:

- (1) Ideal table: error, 3.78 per cent.;
- (2) Baldwin's table: error, 4.92 per cent.

#### RESULTS REGARDING CHEST GIRTH

The estimated chest girth for age deviated from the observed girth, according to

- (1) Ideal table, by 4.50 per cent.;
- (2) Porter's table, by 6.52 per cent.

RESULTS REGARDING WEIGHT

The relative accuracy of the six standards for estimating normal weight was, giving the best first:

- (1) Ideal table of weight-for-height and ideal table of weight-for-chest, combined: error, 4.87 per cent.
- (2) Ideal table of weight-for-chest: error, 5.35 per cent.
- (3) Wood's table of weight for height, minus Bowditch's varying allowances for clothes: error, 7.17 per cent.
- (4) Bornhardt's formula: error, 7.25 per cent.
- (5) Ideal table of weight for height according to averages by inches of height, with weights for half-inches interpolated: error, 7.57 per cent.
- (6) Wood's table of weight for height, corrected to give net weight by subtracting four pounds throughout, as advised by Wood: error, 8.27 per cent.

TABLE 4.—THIN AND FAT BOYS

Difference Between Predicted Weight (PW) and Actual Weight (W), in in Percentage of Actual Weight		No. of Boys
Thin		
	PW greater than W by 11 per cent. and over (maximum 16 per cent.)..	11
	By 1—10 per cent.....	61
	PW = W.....	9
Fat		
	PW less than W by 1—10 per cent.....	52
	11 per cent. and over (highest 14 per cent.).....	3
Sum		136

DISTRIBUTION OF THIN AND FAT BOYS IN THIS SCHOOL

The material in hand may now be regarded from another point of view, that of the individual. If the proposed ideal standard be accepted as the most suitable for judging this type of private country school boy, how do the boys in the present series measure up to it? How many are too thin? How many, if any, are too fat?

This may be roughly shown by tabulating the "percentage errors" in groups, as in Table 4.

For this purpose the better procedure would be to recalculate the difference between the predicted and actual weights, referring the percentage to the predicted weight instead of to the actual weight. The greater accuracy thus obtainable has not seemed worth the labor, for our present purposes.

The results are: (1) only eleven boys, or 8 per cent. of the series, are excessively thin; (2) only three boys, or 2 per cent., are too fat; (3) the underweights and overweights in general are about equal in number, as was to be expected, since these observations were utilized in constructing the ideal standard. This fact, it is true, to a consid-

erable degree invalidates the value of this standard for judging these particular boys individually, because the boys seem nearer normal than they may fairly be said to be. This vitiation, however, is unavoidable till an ideal table based on larger material be available.

#### SUMMARY

1. For judging the size and weight of children of the "higher economic classes" (Faber<sup>13</sup>), i.e., of boarding and country day-school boys (not including private schools in the city), totally new standards are necessary.

2. Such standards are tentatively offered, for predicting (and judging the normality of) weight, height, and chest girth.

3. These standards, together with representatives of current standards, are tested by the simplest and briefest mathematical method (laborious at that, thus probably explaining the lack hitherto of such data).

4. The results are sufficiently favorable to the proposed methods to indicate further study, and this has been done on data obtained from a similar boarding school, Middlesex, at Concord, Mass.<sup>14</sup>

We are indebted for the opportunity to make this study to the founder and present headmaster of the school, the Reverend Endicott Peabody.

---

13. Faber, H. K.: *Arch. Pediat.* **37**:244 (April) 1920.

14. Gray, H.: *Size and Weight in 130 Boarding School Boys (Middlesex)* M. Clin. of N. America, May, 1921.