# HEIGHT AND WEIGHT MEASUREMENTS OF SCHOOL CHILDREN

By B. BENJAMIN, B.Sc., F.I.A., F.S.S., *L.C.C. Public Health Department*

(With 1 Figure in the Text)

## Data

In 1938 the London County Council (1940) made a survey of height and weight records of elementary school children in order to obtain up-to-date averages against which individual children could be compared. The necessity for conducting the survey with the least possible interruption in the normal routine of the school medical service prevented any detailed analysis of the whole data. Copies of individual records were, however, prepared in respect of a random section of two metropolitan boroughs—Bermondsey and Lewisham—and the following analysis is based thereon. The particulars shown on the height and weight cards (which were transferred to punched cards for tabulation) consisted of observations, over a period from 1935, or date of entry if later, to 1938, and separated by intervals of 6 months, on the average. It should be noted that children were measured in ordinary indoor clothing, but without footwear; heights were recorded to the nearest centimetre, and weights in kilogrammes to the nearest decimal. Cards were available for about 2000 children of each sex.

## Objective

When the report on the 1938 averages was published, the *Lancet* (1940) expressed regret that frequency distributions were not included in the report. For the administrative reason already referred to, the averages had been calculated by straightforward addition of the observations, the height-weight cards being returned to the schools as soon as the readings had been included in the appropriate age-group totals, and no frequency distributions were available. In an attempt partly to repair this omission the present study gives specimen frequency distributions for the sample of records relating to Bermondsey and Lewisham.

In addition, an attempt has been made to examine the seasonal variation of the rate of growth of the school child.

## Frequency distributions

The sample height and weight distributions are shown in Tables 1–4. Since working standards of height and weight were not required but only distribution characteristics, seasonal variation was excluded as far as possible by taking spring observations only. The age groups corresponded to those of the 'spring' measurements (March–May) of the 1938 investigation, i.e. observations were grouped according to the difference between year of birth and year of observation ('spring').

The actual average age of each group was also determined subsequently by sorting the cards according to month of birth and month of observation.

This method of grouping ages has the effect of giving to each age group a spread of approximately $1\frac{1}{4}$ years, viz. in the age groups corresponding to 'year of observation less year of birth $=x$', the oldest possible child in this group will at the March to May period

https://doi.org/10.1017/S0022172400035853 Published online by Cambridge University Press

be $(x+\frac{5}{12})$ exactly and the youngest $(x-\frac{10}{12})$ exactly. The frequency distributions are therefore more dispersed than those relating to exact ages, and this should be borne in mind in examining the distributions. It appears likely that the standard deviations for the groups given in Tables 1–4 are at least 10% in excess of those for groups of children all of an age *exactly* equal to the average of the respective groups. No adjustment has been made because the conditions of practice entail the broad comparison against a scale (limited to certain specified values separated by quarterly intervals) of children who are known to fall in a specified age group but whose *exact* ages are not taken into account. The distributions have been in fact expressed in the manner in which they could most easily be used.

In order to cover the school life as completely as possible, distributions have been given for children in the age groups ('year of observation *less* year of birth') 12 and 13. The numbers here are very small and errors in measurement are likely to have an inordinately large effect on the distributions. The figures should therefore be accepted with due reservation.

## Seasonal variation of growth

In order to assess the seasonal variation of the rate of increase in height and weight, the periods of growth represented by the intervals between the successive readings on the cards were scheduled first according to the initial and then according to the final dates of observation. Boys and girls were scheduled separately but in order to get groups of suitable magnitude it was necessary to combine the ages. This combination at once gave rise to difficulties. Although it is doubtful whether there is any variation of the seasonal effect with age it is certain that the rate of growth varies with age (considerably less for height than for weight). Any comparison of absolute rates of growth for the different intervals would therefore be predominantly affected by the variation in the average age of the groups from which each interval rate was derived. It was decided to exclude the age factor as far as possible by expressing the actual rate of growth as a proportion of the rate of growth expected (at the average age of the group) if growth had followed the curve obtained by graduating the 1938 averages for the combined metropolitan boroughs of Bermondsey and Lewisham. Such a curve provided a suitable base line since it ran through the summer and autumn measurements of 1938 and was thus devoid of seasonal fluctuations.

## Growth curves for Bermondsey and Lewisham combined data

Curves, similar to those produced for the County of London in the 1938 report, were fitted by the method of least squares to the combined data for Lewisham and Bermondsey (i.e. the complete data of the 1938 investigation, not that of the sample of cards on which this study is based). These curves were found to be as follows where $Y$ is height or weight and $X$ is exact age:

Height (cm.):

Boys: $Y=71{\cdot}8765+7{\cdot}38009X-0{\cdot}122312X^2$.

Girls: $Y=78{\cdot}6661+5{\cdot}39484X$.

Weight (kg.):

Boys $\log_{10}$: $Y=1{\cdot}05062+0{\cdot}0441576X-0{\cdot}000166750X^2$.

Girls $\log_{10}$: $Y=1{\cdot}08983+0{\cdot}0294310X+0{\cdot}000826236X^2$.

## SEASONAL RATES OF GROWTH

When the expected rates of growth at the appropriate ages had been calculated, the ratios of actual to expected rates of growth were scheduled according to the central date of the growth period and the results are shown in Tables 5–8.

The average values obtained therefrom are represented in the figures at the end of this report. In examining the figures it is important to remember that the curves are obtained by joining together a discontinuous series of observations of very unequal weight. For certain intervals there are no observations at all. Fluctuations founded only on very small groups of children should be adequately discounted (though it would have been improper to exclude these from the tables and diagrams).

Very little importance, therefore, can be attached to the following observations:

| Sex | Central date of growth period |
|---|---|
| Boys | Mid-March, Mid-May, End of August |
| *Girls* | *Mid-March, End of March, Mid-April, Mid-May, End of October, Mid-November* |

If these observations are ignored the following tentative conclusions can be drawn:

(1) *Height.* The maximum rate of height growth appears from the boys' curve to lie between the end of February and the end of May. In the girls' curve the rate of growth does not begin to decline until after the middle of July, which suggests that the maximum lies near the latter of the two limits shown by the boys' curve, i.e. in the late spring. (The two curves have been considered together here because generally there is such close similarity between them as to suggest that there is no difference in the seasonal rhythm of the two sexes.) The minimum rate of height growth appears to be reached after the middle of August and before the end of November. Mid-autumn is suggested as a reasonable assumption.

(2) *Weight.* The rate of growth in weight appears to reach a maximum in December, i.e. at the end of the autumn, and to fall to a minimum during May, i.e. in the middle of the spring.

(3) The seasonal fluctuation in the rate of growth appears to be more substantial in weight than in height. It is well known, of course, that weight is more sensitive than height to changes in health. Generally we have much more external control over weight growth than over height growth. The greater sensitivity to seasonal changes of weight increase is therefore not surprising.

For the above purposes the seasons are defined as follows: January–March—winter; April–June—spring; July–September—summer; October–December—autumn.

## LIMITATIONS OF THE DATA

The data were not intended to be used for an examination of seasonal changes and it is worth while considering in detail the difficulties arising from an attempt to use them for such a purpose.

(*a*) No information is available as to the seasonal variation in the weight of clothing. Although reduced to a minimum by the condition that the measurements are made in ordinary indoor clothing *without* boots, the variation is still not inconsiderable, and tends to distort the growth rates for intervals in respect of which the terminal measurements fall in periods of heavier or lighter clothing than those of the initial measurements. If we can assume that a sharp increase in the weight of indoor clothing occurs at the

https://doi.org/10.1017/S0022172400035853 Published online by Cambridge University Press

beginning of November and a marked reduction occurs at the beginning of May, then for intervals of 6 months the apparent rates of weight growth will be increased for central dates August to January inclusive, and reduced for central dates February to July inclusive. This will tend to shift the maximum rate of growth toward November and the minimum toward May. The variation in clothing will also tend to accentuate the seasonal fluctuation in weight growth.

Height variation is, of course, unaffected by clothing, and the fact that in the diagram periods of maximum weight increase are periods of minimum height increase and vice versa suggests that the distortion of the weight curve due to clothing changes is not very great. The sharp rise in the rate of weight increase in December must, however, be suspect.

(*b*) The rates of growth used in the analysis are based upon periods (of about 6 months), which are long in comparison with the length of the cycle of variation, and consequently the method adopted tends to smooth out the seasonal variations, and to reduce the apparent fluctuations. This compensates to an unknown extent for the accentuation of the fluctuations caused by the clothing changes.

It is probable that the true curve of seasonal variation has many changes of curvature because the biological rhythm is likely to be affected by weather changes, dietary changes, changes in activity and changes in sleeping habits, throughout the year. (School holidays may have a considerable effect.) In this connexion it should be noted that, at a boarding school in the south of England (Allan, 1937) and at secondary schools in Leeds (Allan, 1939), Allan has found that apart from seasonal fluctuation there is a period at the end of every term when there is a reduction in the number of children who gain weight and in the amount of weight gained. Even those who gain weight in each month of the term do so more slowly in the final month. Some reduction in the increase in height is often noticeable at the end of the school term. There is an acceleration in the rate of increase in height and weight during holidays. In height this is especially noticeable during the spring holidays when the rate is higher than at any other point of the year. There is an interesting contrast between day-school and boarding-school boys during the Christmas holidays when the rate of increase in weight for day schools is much higher than for boarding schools. Allan considers that this is partly due to the reaction of day-school children to their longer autumn term, and partly due to the fact that in boarding schools the change of environment acts as a stimulus to weight gains after the holidays so that periods of most rapid gain occur in the early parts of the school terms rather than during holidays. The results of the investigation indicate that the balance between work and play in the school routine has an important effect upon growth.

(*c*) The data as a whole are scanty. In particular there are few measurements of growth periods which have central dates in the periods March to April inclusive and August to October inclusive, so that at these parts of the year the curve of seasonal variation is based upon very uncertain data.

## Other investigations

Few detailed studies of seasonal fluctuation in growth of school children have been undertaken in Great Britain. Dr Friend's (1935) careful study of the growth of boys at Christ's Hospital, Horsham, leads to the conclusion 'that the maximum rate of increase in height occurs during the spring, while that for weight occurs in the autumn', but the data were not in a form which allowed a more specific estimate of the times of the peak rates of growth to be made. Orr & Clarke (1930), in a study of 657 Scottish school children, found that the maximum rate of increase in height occurred between April and June and the minimum rate occurred between October and December; the maximum rate of increase in weight occurred between July and September and the minimum rate occurred between April and June (in this quarter 25% of boys actually lost weight although increasing in height). These findings were consistent with the results of the researches of the Milk Nutrition Committee (1939) on the growth of school children. Dr Mumford's (1927) measurements of a small number of boys at Manchester Grammar School in 1914–15 indicate a maximum rate of height growth in spring and early summer and a maximum rate of weight growth in the autumn.

The only inconsistency between these investigations and the present study lies in the fact that whereas Orr & Clarke found the maximum weight increase to be in the season (i.e. summer) immediately following the season of maximum height growth, the L.C.C. children do not appear to reach their maximum rate of weight increase until the late autumn, i.e. 6 months after the maximum rate of height increase has been reached. It has already been admitted that the L.C.C. measurements, unlike the Scottish measurements, do not take into account the variation in the weight of clothing; this would tend to throw the maximum weight increase toward the season of cold weather. Another factor to be taken into account is the difference between the meteorological conditions of London and Scotland (the children attended schools in Glasgow, Edinburgh, Dundee, Peterhead and Greenock).

## Scope for further research

The data available in this investigation were neither of sufficient size and homogeneity nor were they arranged in the form suitable for a complete analysis to be made, and it would, therefore, be futile to attempt to draw any *quantitative* conclusions. Precise knowledge of the periods of maximum growth and of the extent of the seasonal variation would make it possible to assess the dietary requirements of school children at different periods of the calendar year, and would make it possible to differentiate more clearly between fluctuations due to seasonal causes and those due to changes in health. It is to be hoped, therefore, that it will not be long before further research is undertaken with the object of obtaining more precise information.

## Summary

Sample frequency distributions are given of height and weight measurements of London elementary school children made during the period 1935–8. In addition these measurements have been analysed in order to determine the seasonal fluctuation in rates of growth. The rate of increase in height appears to reach a maximum in the latter part of spring and a minimum in the middle of autumn. The rate of increase in weight appears to reach a maximum in the latter part of autumn and a minimum in the middle of spring. Tables and graphs are given showing, for each sex, the variation in the rates of growth throughout the calendar year.

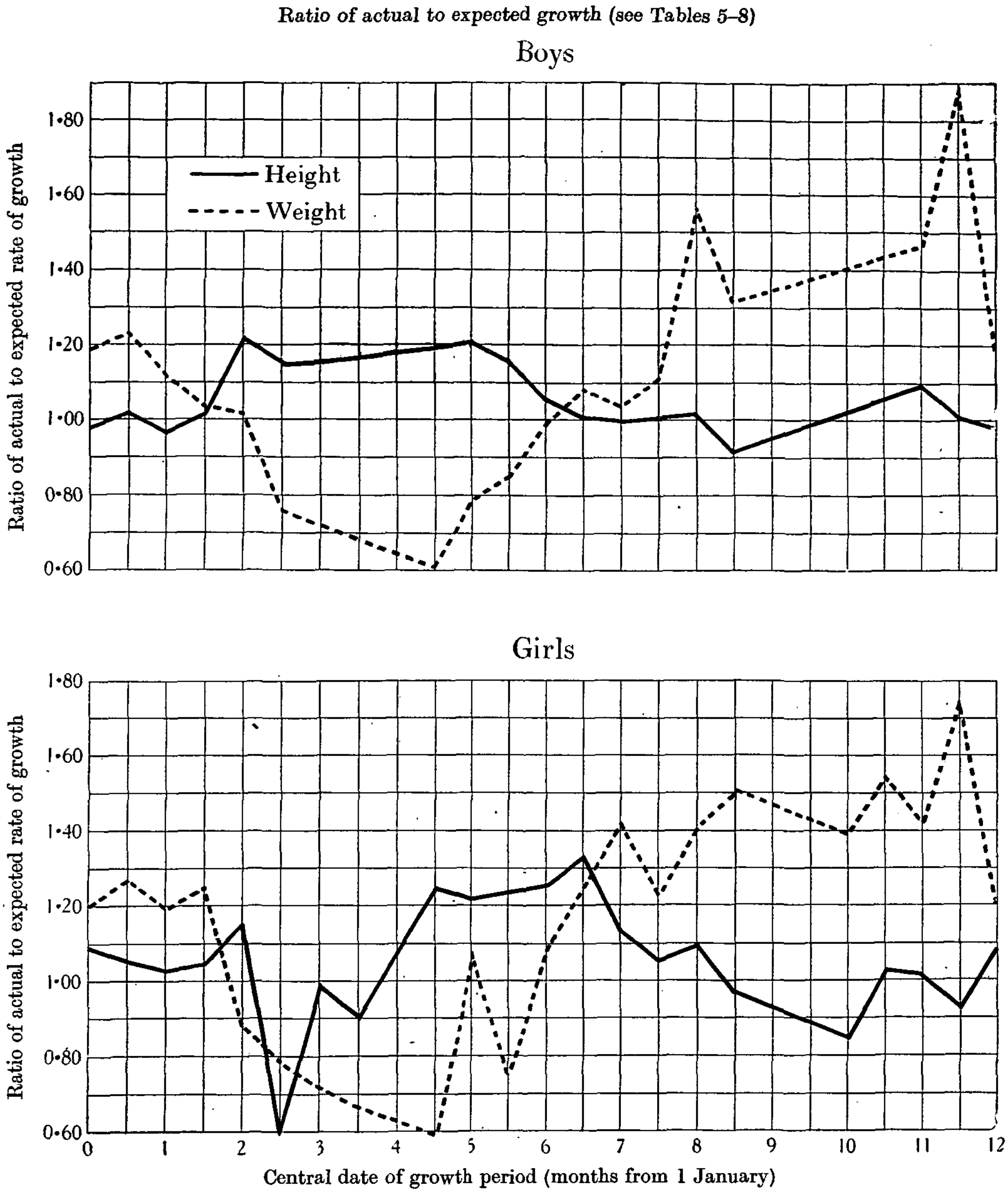


**Fig. 1.**

https://doi.org/10.1017/S0022172400035853 Published online by Cambridge University Press

## APPENDIX

### Table 1. *Height distribution—Boys*

| Height to nearest cm. | Year of observation *less* year of birth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 85– 89 | 1 | — | — | — | — | — | — | — | — | — |
| 90– 94 | 11 | 1 | — | — | — | — | — | — | — | — |
| 95– 99 | 41 | 27 | 3 | — | — | — | — | — | — | — |
| 100–104 | 20 | 69 | 33 | 3 | 1 | — | — | — | — | — |
| 105–109 | 8 | 56 | 126 | 27 | 2 | — | — | — | — | — |
| 110–114 | 1 | 18 | 140 | 100 | 27 | 2 | — | — | — | — |
| 115–119 | — | 2 | 55 | 113 | 96 | 24 | — | — | — | — |
| 120–124 | — | 2 | 6 | 65 | 121 | 72 | 13 | 1 | — | — |
| 125–129 | — | — | 1 | 13 | 87 | 84 | 59 | 27 | 1 | — |
| 130–134 | — | — | — | 1 | 25 | 62 | 85 | 49 | 7 | 1 |
| 135–139 | — | — | — | — | 4 | 16 | 43 | 61 | 14 | 4 |
| 140–144 | — | — | — | — | — | 3 | 13 | 43 | 17 | 15 |
| 145–149 | — | — | — | — | — | — | 4 | 16 | 11 | 11 |
| 150–154 | — | — | — | — | — | — | — | 3 | 3 | 9 |
| 155–159 | — | — | — | — | — | — | — | 1 | 1 | 2 |
| 160–164 | — | — | — | — | — | — | — | — | 1 | 2 |
| Total | 82 | 175 | 364 | 322 | 363 | 263 | 217 | 201 | 55 | 44 |
| Average age (years) | 3·91 | 4·80 | 5·77 | 6·75 | 7·78 | 8·74 | 9·81 | 10·74 | 11·73 | 12·59 |
| Mean height | 98·6 | 104·2 | 110·2 | 115·9 | 121·8 | 126·6 | 131·9 | 136·6 | 141·4 | 146·2 |
| S.D. | 4·54 | 5·00 | 4·73 | 5·18 | 5·63 | 5·66 | 5·28 | 6·25 | 6·68 | 6·48 |
| Ratio of S.D. to mean | 0·046 | 0·048 | 0·043 | 0·045 | 0·046 | 0·045 | 0·040 | 0·046 | 0·047 | 0·044 |
| S.D. of mean | 0·502 | 0·378 | 0·248 | 0·289 | 0·296 | 0·349 | 0·358 | 0·441 | 0·900 | 0·977 |

### Table 2. *Height distribution—Girls*

| Height to nearest cm. | Year of observation *less* year of birth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 85– 89 | 3 | — | — | — | — | — | — | — | — | — |
| 90– 94 | 28 | 3 | 1 | — | — | — | — | — | — | — |
| 95– 99 | 36 | 24 | 5 | 1 | — | — | — | — | — | — |
| 100–104 | 23 | 68 | 40 | 5 | — | — | — | — | — | — |
| 105–109 | 5 | 68 | 127 | 40 | 8 | — | — | — | — | — |
| 110–114 | — | 12 | 114 | 93 | 25 | 9 | — | — | — | — |
| 115–119 | — | 1 | 42 | 95 | 89 | 34 | 5 | 2 | — | — |
| 120–124 | — | 1 | 9 | 58 | 126 | 75 | 20 | 7 | — | — |
| 125–129 | — | — | 1 | 5 | 51 | 76 | 56 | 17 | 2 | — |
| 130–134 | — | — | — | 1 | 14 | 42 | 53 | 62 | 8 | — |
| 135–139 | — | — | — | — | 2 | 10 | 25 | 63 | 12 | 4 |
| 140–144 | — | — | — | — | — | 1 | 17 | 29 | 14 | 9 |
| 145–149 | — | — | — | — | — | — | — | 12 | 9 | 10 |
| 150–154 | — | — | — | — | — | — | — | 3 | 4 | 12 |
| 155–159 | — | — | — | — | — | — | — | 1 | — | 8 |
| 160–164 | — | — | — | — | — | — | — | — | — | 4 |
| Total | 95 | 177 | 339 | 298 | 315 | 247 | 176 | 196 | 49 | 47 |
| Average age (years) | 3·84 | 4·85 | 5·75 | 6·76 | 7·77 | 8·71 | 9·80 | 10·74 | 11·57 | 12·72 |
| Mean height | 96·9 | 103·9 | 109·6 | 115·0 | 120·8 | 124·9 | 130·5 | 135·5 | 140·3 | 149·4 |
| S.D. | 4·67 | 4·60 | 5·13 | 5·43 | 5·39 | 5·85 | 6·06 | 6·46 | 6·43 | 7·06 |
| Ratio of S.D. to mean | 0·048 | 0·044 | 0·047 | 0·047 | 0·045 | 0·047 | 0·046 | 0·048 | 0·046 | 0·047 |
| S.D. of mean | 0·479 | 0·346 | 0·279 | 0·315 | 0·304 | 0·372 | 0·457 | 0·461 | 0·919 | 1·030 |

https://doi.org/10.1017/S0022172400035853 Published online by Cambridge University Press

Table 3. *Weight distribution—Boys*

| Weight to nearest $\frac{1}{10}$ kg. | Year of observation *less* year of birth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 12– | — | — | — | — | — | — | — | — | — | — |
| 13– | 5 | — | — | — | — | — | — | — | — | — |
| 14– | 15 | 9 | 1 | — | — | — | — | — | — | — |
| 15– | 21 | 22 | 10 | — | — | — | — | — | — | — |
| 16– | 15 | 29 | 16 | 2 | 1 | — | — | — | — | — |
| 17– | 15 | 39 | 48 | 12 | 1 | — | — | — | — | — |
| 18– | 6 | 30 | 68 | 25 | 5 | — | — | — | — | — |
| 19– | 2 | 16 | 68 | 33 | 19 | 1 | — | — | — | — |
| 20– | 3 | 11 | 57 | 57 | 21 | 8 | — | — | — | — |
| 21– | — | 10 | 41 | 49 | 41 | 11 | — | — | — | — |
| 22– | — | 6 | 25 | 51 | 40 | 16 | 4 | — | — | — |
| 23– | — | 1 | 18 | 39 | 67 | 23 | 5 | 2 | — | — |
| 24– | — | 1 | 8 | 24 | 47 | 34 | 8 | 5 | 1 | — |
| 25– | — | 1 | 2 | 18 | 40 | 36 | 20 | 8 | — | — |
| 26– | — | — | 1 | 4 | 29 | 22 | 26 | 6 | — | — |
| 27– | — | — | — | 2 | 11 | 31 | 25 | 12 | 1 | — |
| 28– | — | — | 1 | 2 | 13 | 32 | 30 | 18 | 5 | — |
| 29– | — | — | — | 3 | 12 | 15 | 26 | 14 | 3 | — |
| 30– | — | — | — | — | 5 | 13 | 21 | 29 | 1 | 1 |
| 31– | — | — | — | — | 7 | 9 | 8 | 23 | 3 | 2 |
| 32– | — | — | — | — | 1 | 4 | 10 | 18 | 4 | 3 |
| 33– | — | — | — | 1 | 1 | 4 | 15 | 13 | 9 | 7 |
| 34– | — | — | — | — | — | 3 | 8 | 13 | 6 | 3 |
| 35– | — | — | — | — | 2 | 1 | 4 | 10 | 4 | 5 |
| 36– | — | — | — | — | — | — | 3 | 8 | 4 | 2 |
| 37– | — | — | — | — | — | — | 1 | 6 | 4 | 1 |
| 38– | — | — | — | — | — | — | 1 | 6 | 6 | 3 |
| 39– | — | — | — | — | — | — | 1 | 5 | 1 | 3 |
| 40– | — | — | — | — | — | — | 1 | 2 | 1 | 2 |
| 41– | — | — | — | — | — | — | — | 2 | — | 2 |
| 42– | — | — | — | — | — | — | — | — | — | 1 |
| 43– | — | — | — | — | — | — | — | 1 | 1 | 4 |
| 44– | — | — | — | — | — | — | — | — | — | — |
| 45– | — | — | — | — | — | — | — | — | 1 | 3 |
| 46– | — | — | — | — | — | — | — | — | — | 1 |
| 47– | — | — | — | — | — | — | — | — | — | — |
| 48– | — | — | — | — | — | — | — | — | — | — |
| 49– | — | — | — | — | — | — | — | — | — | — |
| 50– | — | — | — | — | — | — | — | — | — | 1 |
| Total | 82 | 175 | 364 | 322 | 363 | 263 | 217 | 201 | 55 | 44 |
| Average age (years) | 3·91 | 4·80 | 5·77 | 6·75 | 7·78 | 8·74 | 9·81 | 10·74 | 11·73 | 12·59 |
| Mean weight | 16·19 | 17·94 | 19·72 | 21·76 | 24·08 | 26·35 | 29·05 | 31·66 | 34·21 | 37·79 |
| S.D. | 1·66 | 2·15 | 2·16 | 2·46 | 3·03 | 3·13 | 3·37 | 3·94 | 4·01 | 4·82 |
| Ratio of S.D. to mean | 0·102 | 0·120 | 0·110 | 0·113 | 0·126 | 0·119 | 0·116 | 0·125 | 0·117 | 0·127 |
| S.D. of mean | 0·183 | 0·162 | 0·113 | 0·137 | 0·159 | 0·193 | 0·229 | 0·278 | 0·541 | 0·726 |

https://doi.org/10.1017/S0022172400035853 Published online by Cambridge University Press

Table 4. *Weight distribution—Girls*

| Weight to nearest $\frac{1}{10}$ kg. | Year of observation *less* year of birth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 11– | 1 | — | — | — | — | — | — | — | — | — |
| 12– | 4 | — | — | — | — | — | — | — | — | — |
| 13– | 8 | 3 | — | — | — | — | — | — | — | — |
| 14– | 17 | 8 | 8 | 1 | — | — | — | — | — | — |
| 15– | 29 | 28 | 11 | 4 | — | — | — | — | — | — |
| 16– | 16 | 39 | 32 | 3 | 1 | — | — | — | — | — |
| 17– | 12 | 42 | 58 | 24 | 2 | 2 | — | — | — | — |
| 18– | 5 | 28 | 60 | 21 | 14 | 3 | — | — | — | — |
| 19– | — | 15 | 66 | 57 | 18 | 1 | — | — | — | — |
| 20– | 3 | 4 | 42 | 47 | 33 | 13 | — | — | — | — |
| 21– | — | 6 | 23 | 43 | 35 | 18 | 6 | 1 | — | — |
| 22– | — | 2 | 23 | 39 | 46 | 31 | 5 | 2 | — | — |
| 23– | — | 1 | 8 | 23 | 53 | 27 | 10 | 3 | — | — |
| 24– | — | 1 | 3 | 11 | 41 | 30 | 11 | 5 | — | — |
| 25– | — | — | 4 | 10 | 21 | 32 | 27 | 7 | 1 | — |
| 26– | — | — | 1 | 6 | 19 | 27 | 19 | 14 | 2 | — |
| 27– | — | — | — | 2 | 14 | 23 | 14 | 14 | 1 | — |
| 28– | — | — | — | 5 | 9 | 11 | 16 | 22 | 2 | 1 |
| 29– | — | — | — | 2 | 4 | 13 | 14 | 30 | 5 | — |
| 30– | — | — | — | — | 2 | 7 | 19 | 20 | 4 | 3 |
| 31– | — | — | — | — | 3 | 2 | 9 | 9 | 6 | 2 |
| 32– | — | — | — | — | — | 3 | 6 | 17 | 7 | — |
| 33– | — | — | — | — | — | 3 | 4 | 9 | 4 | 2 |
| 34– | — | — | — | — | — | — | 6 | 6 | 1 | 4 |
| 35– | — | — | — | — | — | 1 | 5 | 13 | 3 | 3 |
| 36– | — | — | — | — | — | — | 1 | 9 | 2 | 3 |
| 37– | — | — | — | — | — | — | 1 | 3 | 2 | 2 |
| 38– | — | — | — | — | — | — | — | 1 | 2 | 2 |
| 39– | — | — | — | — | — | — | 3 | 4 | 2 | 4 |
| 40– | — | — | — | — | — | — | — | 6 | 3 | 1 |
| 41– | — | — | — | — | — | — | — | 1 | — | 2 |
| 42– | — | — | — | — | — | — | — | — | — | 5 |
| 43– | — | — | — | — | — | — | — | — | 1 | 3 |
| 44– | — | — | — | — | — | — | — | — | — | 2 |
| 45– | — | — | — | — | — | — | — | — | 1 | 3 |
| 46– | — | — | — | — | — | — | — | — | — | 1 |
| 47– | — | — | — | — | — | — | — | — | — | 2 |
| 48– | — | — | — | — | — | — | — | — | — | 1 |
| 49– | — | — | — | — | — | — | — | — | — | 1 |
| Total | 95 | 177 | 339 | 298 | 315 | 247 | 176 | 196 | 49 | 47 |
| Average age (years) | 3·84 | 4·85 | 5·75 | 6·76 | 7·77 | 8·71 | 9·80 | 10·74 | 11·57 | 12·72 |
| Mean weight | 15·67 | 17·37 | 19·09 | 21·06 | 23·22 | 25·06 | 28·14 | 30·79 | 33·39 | 39·22 |
| S.D. | 1·72 | 1·88 | 2·21 | 2·63 | 2·76 | 3·13 | 3·81 | 4·11 | 4·45 | 5·39 |
| Ratio of S.D. to mean | 0·110 | 0·108 | 0·116 | 0·125 | 0·119 | 0·125 | 0·135 | 0·134 | 0·133 | 0·137 |
| S.D. of mean | 0·176 | 0·141 | 0·120 | 0·152 | 0·156 | 0·199 | 0·287 | 0·294 | 0·636 | 0·786 |

Table 5. *Boys—Height*

| Central date of growth period months from 1 January | Length of period months | Number of children observed | Average age of group | Actual rate of growth cm. per annum | Expected rate of growth cm. per annum | Ratio of actual rate to expected rate |
|---|---|---|---|---|---|---|
| ½ | 6 | 1107 | 8·11 | 5·414 | 5·396 | 1·003 |
| | 4 | 96 | 7·10 | 6·531 | 5·643 | 1·157 |
| | | 1203 | 8·03 | 5·503 | 5·416 | 1·016 |
| 1 | 7 | 289 | 8·40 | 5·345 | 5·325 | 1·004 |
| | 5 | 122 | 7·39 | 4·978 | 5·572 | 0·893 |
| | | 411 | 8·10 | 5·236 | 5·399 | 0·970 |
| 1½ | 6 | 451 | 7·46 | 5·544 | 5·555 | 0·998 |
| | 4 | 46 | 6·92 | 6·978 | 5·687 | 1·227 |
| | | 497 | 7·41 | 5·677 | 5·567 | 1·020 |
| 2 | 7 | 59 | 6·63 | 6·886 | 5·758 | 1·196 |
| | 5 | 241 | 8·36 | 6·523 | 5·335 | 1·223 |
| | | 300 | 8·02 | 6·594 | 5·418 | 1·217 |
| 2½ | 4 | 28 | 8·19 | 6·213 | 5·377 | 1·155 |
| 4½ | 8 | 35 | 9·03 | 6·600 | 5·171 | 1·276 |
| | 4 | 12 | 12·46 | 4·000 | 4·332 | 0·923 |
| | | 47 | 9·91 | 5·936 | 4·956 | 1·198 |
| 5 | 7 | 236 | 9·39 | 6·357 | 5·083 | 1·251 |
| | 5 | 75 | 8·83 | 5·760 | 5·220 | 1·103 |
| | | 311 | 9·25 | 6·213 | 5·117 | 1·214 |
| 5½ | 6 | 1741 | 8·41 | 6·218 | 5·323 | 1·168 |
| | 8 | 137 | 7·22 | 5·572 | 5·614 | 0·993 |
| | | 1878 | 8·32 | 6·171 | 5·345 | 1·155 |
| 6 | 7 | 483 | 7·00 | 5·899 | 5·668 | 1·041 |
| | 5 | 128 | 7·79 | 6·226 | 5·474 | 1·137 |
| | | 611 | 7·17 | 5·968 | 5·626 | 1·061 |
| 6½ | 8 | 61 | 8·41 | 6·369 | 5·323 | 1·197 |
| | 6 | 1249 | 8·19 | 5·348 | 5·377 | 0·995 |
| | | 1310 | 8·20 | 5·396 | 5·374 | 1·004 |
| 7 | 7 | 385 | 7·54 | 5·103 | 5·536 | 0·922 |
| | 5 | 469 | 7·45 | 5·911 | 5·558 | 1·064 |
| | | 854 | 7·49 | 5·547 | 5·548 | 1·000 |
| 7½ | 6 | 555 | 7·51 | 5·582 | 5·543 | 1·007 |
| 8 | 7 | 40 | 6·92 | 4·671 | 5·687 | 0·821 |
| | 5 | 55 | 5·90 | 6·895 | 5·937 | 1·161 |
| | | 95 | 6·33 | 5·959 | 5·832 | 1·022 |
| 8½ | 6 | 197 | 8·69 | 4·802 | 5·254 | 0·914 |
| 11 | 5 | 152 | 8·71 | 5·779 | 5·249 | 1·101 |
| 11½ | 6 | 1729 | 8·31 | 5·408 | 5·347 | 1·011 |
| 12 | 7 | 332 | 7·44 | 5·194 | 5·560 | 0·934 |
| | 5 | 478 | 6·92 | 5·753 | 5·687 | 1·012 |
| | | 810 | 7·13 | 5·524 | 5·636 | 0·980 |

Table 6. *Boys—Weight*

| Central date of growth period months from 1 January | Length of period months | Number of children observed | Average age of group | Actual rate of growth kg. per annum | Expected rate of growth kg. per annum | Ratio of actual rate to expected rate |
|---|---|---|---|---|---|---|
| ½ | 6 | 1107 | 8·11 | 2·9368 | 2·3853 | 1·231 |
| | 4 | 96 | 7·10 | 2·7282 | 2·1828 | 1·250 |
| | | 1203 | 8·03 | 2·9202 | 2·3686 | 1·233 |
| 1 | 7 | 289 | 8·40 | 2·3253 | 2·4465 | 0·950 |
| | 5 | 122 | 7·39 | 3·4858 | 2·2393 | 1·557 |
| | | 411 | 8·10 | 2·6697 | 2·3832 | 1·120 |
| 1½ | 6 | 451 | 7·46 | 2·2848 | 2·2531 | 1·014 |
| | 4 | 46 | 6·92 | 2·7978 | 2·1484 | 1·302 |
| | | 497 | 7·41 | 2·3322 | 2·2434 | 1·040 |
| 2 | 7 | 59 | 6·63 | 1·6795 | 2·0940 | 0·802 |
| | 5 | 241 | 8·36 | 2·5822 | 2·4379 | 1·059 |
| | | 300 | 8·02 | 2·4047 | 2·3666 | 1·016 |
| 2½ | 4 | 28 | 8·19 | 1·8321 | 2·4020 | 0·763 |
| 4½ | 8 | 35 | 9·03 | 1·9285 | 2·5842 | 0·746 |
| | 4 | 12 | 12·46 | 1·0000 | 3·4613 | 0·289 |
| | | 47 | 9·91 | 1·6914 | 2·7879 | 0·607 |
| 5 | 7 | 236 | 9·39 | 2·3520 | 2·4035 | 0·979 |
| | 5 | 75 | 8·83 | 1·2065 | 2·5382 | 0·475 |
| | | 311 | 9·25 | 2·0758 | 2·6338 | 0·788 |
| 5½ | 6 | 1741 | 8·41 | 2·0886 | 2·4485 | 0·853 |
| | 8 | 137 | 7·22 | 1·6839 | 2·2061 | 0·763 |
| | | 1878 | 8·32 | 2·0591 | 2·4294 | 0·848 |
| 6 | 7 | 483 | 7·00 | 2·1987 | 2·1637 | 1·016 |
| | 5 | 128 | 7·79 | 2·1262 | 2·3193 | 0·917 |
| | | 611 | 7·17 | 2·1835 | 2·1962 | 0·994 |
| 6½ | 8 | 61 | 8·41 | 2·2304 | 2·4485 | 0·911 |
| | 6 | 1249 | 8·19 | 2·6236 | 2·4020 | 1·092 |
| | | 1310 | 8·20 | 2·6053 | 2·4041 | 1·084 |
| 7 | 7 | 385 | 7·54 | 2·2447 | 2·2690 | 0·989 |
| | 5 | 469 | 7·45 | 3·5340 | 2·2511 | 1·570 |
| | | 854 | 7·49 | 2·9527 | 2·8441 | 1·038 |
| 7½ | 6 | 555 | 7·51 | 2·5222 | 2·2631 | 1·114 |
| 8 | 7 | 40 | 6·92 | 3·0086 | 2·1484 | 1·400 |
| | 5 | 55 | 5·90 | 3·3514 | 1·9623 | 1·708 |
| | | 95 | 6·33 | 3·2070 | 2·0389 | 1·573 |
| 8½ | 6 | 197 | 8·69 | 3·2984 | 2·5090 | 1·315 |
| 11 | 5 | 152 | 8·71 | 3·6962 | 2·5134 | 1·471 |
| 11½ | 6 | 1729 | 8·31 | 4·5718 | 2·4273 | 1·883 |
| 12 | 7 | 332 | 7·44 | 2·6050 | 2·2491 | 1·158 |
| | 5 | 478 | 6·92 | 2·6098 | 2·1484 | 1·215 |
| | | 810 | 7·13 | 2·6078 | 2·1887 | 1·191 |

Table 7. *Girls—Height*

| Central date of growth period months from 1 January | Length of period months | Number of children observed | Average age of group | Actual rate of growth cm. per annum | Ratio of actual rate to expected rate (5·395) |
|---|---|---|---|---|---|
| ½ | 8 | 64 | 6·94 | 4·992 | 0·925 |
| | 6 | 868 | 7·84 | 5·712 | 1·059 |
| | 4 | 85 | 7·26 | 6·072 | 1·126 |
| | | 1017 | 7·73 | 5·697 | 1·056 |
| 1 | 9 | 45 | 11·04 | 5·629 | 1·043 |
| | 7 | 237 | 8·14 | 5·498 | 1·019 |
| | 5 | 55 | 7·18 | 5·846 | 1·084 |
| | | 337 | 8·37 | 5·572 | 1·033 |
| 1½ | 6 | 472 | 7·82 | 5·636 | 1·045 |
| 2 | 7 | 93 | 6·55 | 5·475 | 1·015 |
| | 5 | 214 | 8·85 | 6·562 | 1·216 |
| | | 307 | 8·15 | 6·233 | 1·155 |
| 2½ | 6 | 79 | 8·85 | 2·708 | 0·502 |
| | 8 | 22 | 6·89 | 5·386 | 0·998 |
| | | 101 | 8·42 | 3·291 | 0·610 |
| 3 | 5 | 48 | 6·12 | 5·349 | 0·992 |
| 3½ | 6 | 50 | 7·73 | 4·640 | 0·860 |
| | 4 | 22 | 6·04 | 5·454 | 1·011 |
| | | 72 | 7·21 | 4·889 | 0·906 |
| 4½ | 6 | 54 | 9·68 | 6·704 | 1·243 |
| 5 | 7 | 273 | 9·53 | 6·574 | 1·219 |
| | 5 | 80 | 9·75 | 6·480 | 1·201 |
| | | 353 | 9·58 | 6·553 | 1·215 |
| 5½ | 8 | 97 | 7·44 | 5·429 | 1·006 |
| | 6 | 1258 | 9·92 | 6·794 | 1·259 |
| | | 1355 | 9·74 | 6·696 | 1·241 |
| 6 | 7 | 774 | 7·57 | 6·783 | 1·257 |
| 6½ | 6 | 956 | 7·94 | 7·224 | 1·339 |
| 7 | 7 | 212 | 7·85 | 5·548 | 1·028 |
| | 5 | 295 | 7·39 | 6·533 | 1·211 |
| | | 507 | 7·58 | 6·121 | 1·135 |
| 7½ | 6 | 613 | 8·18 | 5·730 | 1·062 |
| 8 | 7 | 93 | 8·18 | 4·258 | 0·789 |
| | 5 | 92 | 5·80 | 7·644 | 1·417 |
| | | 185 | 7·00 | 5·942 | 1·101 |
| 8½ | 6 | 126 | 8·19 | 5·254 | 0·974 |
| | 4 | 23 | 7·53 | 5·349 | 0·992 |
| | | 149 | 8·09 | 5·269 | 0·977 |
| 10 | 5 | 38 | 9·28 | 4·610 | 0·855 |
| 10½ | 6 | 58 | 11·20 | 5·552 | 1·029 |
| 11 | 7 | 83 | 8·31 | 5·163 | 0·957 |
| | 5 | 81 | 7·14 | 5·837 | 1·082 |
| | | 164 | 7·73 | 5·496 | 1·019 |
| 11½ | 6 | 1590 | 8·07 | 5·060 | 0·938 |
| 12 | 7 | 230 | 7·58 | 5·695 | 1·056 |
| | 5 | 645 | 7·29 | 5·998 | 1·112 |
| | | 875 | 7·37 | 5·918 | 1·097 |

https://doi.org/10.1017/S0022172400035853 Published online by Cambridge University Press

Table 8. *Girls—Weight*

| Central date of growth period months from 1 January | Length of period months | Number of children observed | Average age of group | Actual rate of growth kg. per annum | Expected rate of growth kg. per annum | Ratio of actual rate to expected rate |
|---|---|---|---|---|---|---|
| ½ | 8 | 64 | 6·94 | 2·4375 | 2·0315 | 1·200 |
| | 6 | 868 | 7·84 | 2·9880 | 2·2950 | 1·302 |
| | 4 | 85 | 7·26 | 2·0787 | 2·1211 | 0·980 |
| | | 1017 | 7·73 | 2·8774 | 2·2608 | 1·273 |
| 1 | 9 | 45 | 11·04 | 3·8103 | 3·5974 | 1·059 |
| | 7 | 237 | 8·14 | 2·7943 | 2·3914 | 1·169 |
| | 5 | 55 | 7·18 | 2·9496 | 2·0982 | 1·406 |
| | | 337 | 8·37 | 2·9553 | 2·4682 | 1·197 |
| 1½ | 6 | 472 | 7·82 | 2·8568 | 2·2887 | 1·248 |
| 2 | 7 | 93 | 6·55 | 1·1410 | 1·9280 | 0·592 |
| | 5 | 214 | 8·85 | 2·8363 | 2·6377 | 1·075 |
| | | 307 | 8·15 | 2·1160 | 2·3947 | 0·884 |
| 2½ | 6 | 22 | 6·89 | 1·4727 | 2·0179 | 0·730 |
| | 8 | 79 | 8·85 | 2·0860 | 2·6377 | 0·791 |
| | | 101 | 8·42 | 1·9524 | 2·4852 | 0·786 |
| 3 | 5 | 48 | 6·12 | 1·3051 | 1·8207 | 0·717 |
| 3½ | 6 | 50 | 7·73 | 1·3680 | 2·2608 | 0·605 |
| | 4 | 22 | 6·04 | 1·4727 | 1·8011 | 0·818 |
| | | 72 | 7·21 | 1·4000 | 2·1068 | 0·665 |
| 4½ | 6 | 54 | 9·68 | 1·7666 | 2·9627 | 0·596 |
| 5 | 7 | 273 | 9·53 | 3·3330 | 2·9006 | 1·149 |
| | 5 | 80 | 9·75 | 2·6131 | 2·9920 | 0·873 |
| | | 353 | 9·58 | 3·1698 | 2·9211 | 1·085 |
| 5½ | 8 | 97 | 7·44 | 1·3299 | 2·1734 | 0·612 |
| | 6 | 1258 | 9·92 | 2·3212 | 3·0647 | 0·757 |
| | | 1355 | 9·74 | 2·2502 | 2·9878 | 0·753 |
| 6 | 7 | 774 | 7·57 | 2·4193 | 2·2122 | 1·094 |
| 6½ | 6 | 956 | 7·94 | 2·9036 | 2·3267 | 1·248 |
| 7 | 7 | 212 | 7·85 | 2·7268 | 2·2982 | 1·187 |
| | 5 | 295 | 7·39 | 3·4567 | 2·1589 | 1·601 |
| | | 507 | 7·58 | 3·1514 | 2·2152 | 1·423 |
| 7½ | 6 | 613 | 8·18 | 2·9798 | 2·4045 | 1·239 |
| 8 | 7 | 93 | 8·18 | 2·9217 | 2·4045 | 1·215 |
| | 5 | 92 | 5·80 | 2·8824 | 1·7449 | 1·652 |
| | | 185 | 7·00 | 2·9022 | 2·0480 | 1·417 |
| 8½ | 6 | 126 | 8·19 | 3·3746 | 2·4068 | 1·402 |
| | 4 | 23 | 7·53 | 4·6827 | 2·2002 | 2·128 |
| | | 149 | 8·09 | 3·5765 | 2·3749 | 1·506 |
| 10 | 5 | 38 | 9·28 | 3·9158 | 2·8013 | 1·398 |
| 10½ | 6 | 58 | 11·20 | 4·8688 | 3·1402 | 1·551 |
| 11 | 7 | 83 | 8·31 | 3·4843 | 2·4479 | 1·423 |
| | 5 | 81 | 7·14 | 2·9453 | 2·0870 | 1·411 |
| | | 164 | 7·73 | 3·2181 | 2·2608 | 1·423 |
| 11½ | 6 | 1590 | 8·07 | 4·1452 | 2·3686 | 1·750 |
| 12 | 7 | 230 | 7·58 | 2·8308 | 2·2152 | 1·278 |
| | 5 | 645 | 7·29 | 2·4986 | 2·0812 | 1·201 |
| | | 875 | 7·37 | 2·5859 | 2·1529 | 1·201 |

I wish to thank the County Medical Officer of Health, W. Allen Daley, M.D., F.R.C.P., for permission to publish this paper and for encouragement in its preparation; Mr L. Coward, F.I.A., and Mr E. Lewis Faning, Ph.D., for statistical criticism; and Mr J. H. Farrar for drawing the diagrams.

The London County Council takes no responsibility for the views expressed in this paper which are personal only.

REFERENCES

Allan, J. (1937). *Lancet*, **1**, 674.

Allan, J. (1939). *Lancet*, **1**, 1300.

Friend, G. E. (1935). *The School Boy.*

*Lancet* (1940), **1**, 841.

London County Council (1940). *Report of the School Medical Officer on Average Heights and Weights of Elementary School Children*, no. 3464, p. 22.

Mumford, A. A. (1927). *Healthy Growth.*

National Institute for Research in Dairying (1939). *Milk and Nutrition*, Pt. iv.

Orr, J. B. & Clarke, M. L. (1930). *Lancet*, **2**, 558.

(*MS. received for publication* 17. ix. 42.—Ed.)