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The Assessment of the Growth of Schoolchildren with Special Reference to Secular Changes*

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An interesting phenomenon, prominent in the present century, is a secular change in the pattern of growth of schoolchildren. It is usually regarded simply as an increase in the average height and weight of children of school age. This aspect, however, may be misleading and is not altogether satisfactory for comparative purposes. The change was therefore investigated, first in terms of age of attaining a given height or a given weight, and then in terms of rate of growth. This approach leads to the view that the secular change in the pattern of growth is essentially an acceleration.

METHODS AND RESULTS

Data surveyed

The figures dealt with here have been confined to the measurements of boys in Glasgow and London and two sets of data for England as a whole. In 1905–6 a very extensive survey was made of the heights and weights of Glasgow schoolchildren, the occupation of their parents, the number of rooms occupied and other similar information. The schools from which the children came were divided into four groups.

Group A comprised schools in the poorest districts of the city, group B in poor districts of the city, group C in better-class districts and group D in districts of a still higher class, including four out of five Higher Grade Schools.

* An abridged version of this paper was read at the sixty-third scientific meeting of The Nutrition Society on 14 October 1950, the topic under discussion being *Growth.*

Some of these data were later analysed by Miss Elderton (Elderton, 1914) and her paper gives a very complete picture of the heights and weights of Glasgow schoolchildren at that time. Average heights and weights of Glasgow schoolchildren from 1910 to 1949 are available in a series of annual reports by the Education Health Service of the Corporation of Glasgow (see, for example, Ewan, 1950; Young, 1945). The measuring was suspended during the first World War and also in 1940. The figures are otherwise complete for three age groups only, namely 5, 9 and 13 years.

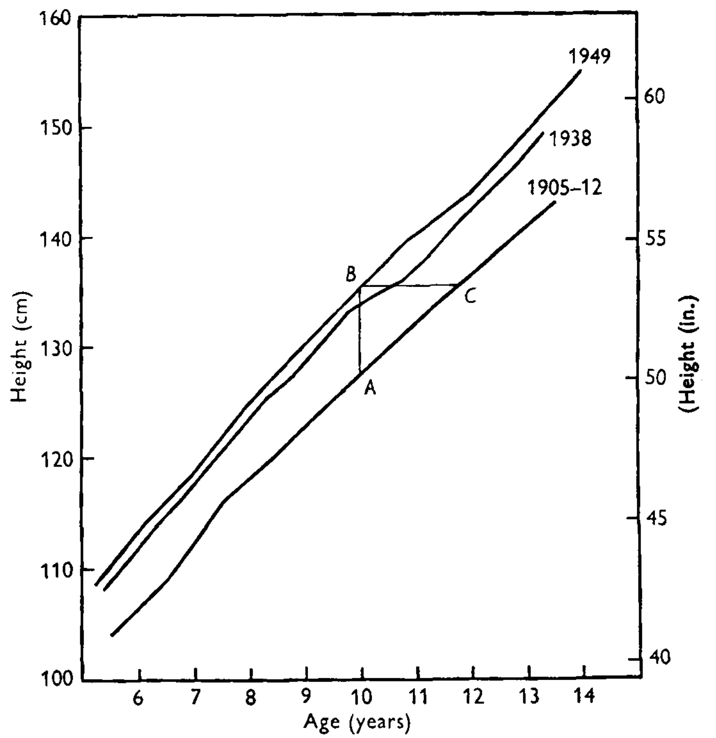

Fig. 1. Secular changes in growth of London schoolboys. Two points of view are indicated; *AB* represents the increase in height at a given age and *BC* the earlier attainment of a given height.

The measurements of London schoolchildren in the years 1905–12, 1938 and 1949 are given in two London County Council Reports (Menzies, 1940; Daley, 1950). The former also quotes some data for English elementary schoolchildren in 1909 and in 1927. All five sets of data cover the age groups 5–14 years.

London measurements

The relation of the average heights of London schoolboys to age is shown in Fig. 1 for the years 1905–12, 1938 and 1949. The corresponding curves for weight are shown in Fig. 2. It is clear that there has been a considerable increase in both height and weight between 1905–12 and 1938, that the process has continued to 1949 and that it applies to all ages. The increase in height appears approximately constant at all ages, but it is evident that the increase in weight is progressive with age. The increases in the measurements adjusted as described below (p. 24) to the stated ages are given in Table 1. The changes in height do in fact increase somewhat with age. The 1905–12 to 1938 interval suggests a decline through the age groups in the percentage increase of height, but the longer interval 1905–12 to 1949 shows that it is almost constant at all ages. The actual increases in weight are definitely progressive and even the percentage increase shows an upward tendency.

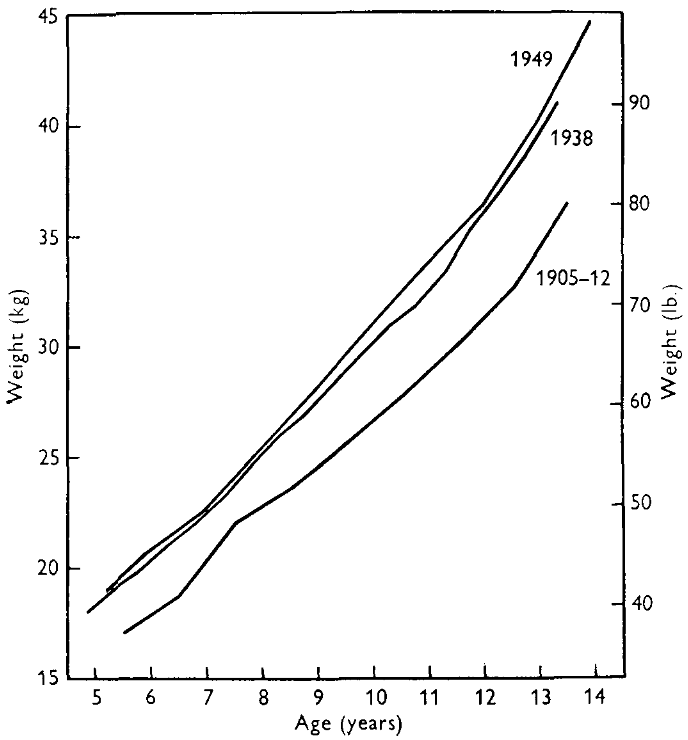

Fig. 2. Secular changes in growth of London schoolboys. Relation of weight to age.

Table 1. *Secular changes in average height and weight of London boys (modified from Menzies,* 1940, *Table V and Daley,* 1950, *Table* 4)

Central age (years)	Height: Excess of 1938 over 1905–12 (cm)	(%)	Height: Excess of 1949 over 1938 (cm)	(%)	Height: Excess of 1949 over 1905–12 (cm)	(%)	Weight: Excess of 1938 over 1905–12 (kg)	(%)	Weight: Excess of 1949 over 1938 (kg)	(%)	Weight: Excess of 1949 over 1905–12 (kg)	(%)
5·5	5·1	4·9	1·4	1·28	6·5	6·24	2·4	14·1	0·23	1·19	2·6	15·2
6·5	5·9	5·4	1·3	1·12	7·2	6·60	2·7	14·4	0·25	1·17	3·0	15·9
7·5	4·5	3·9	1·5	1·24	6·0	5·17	1·7	7·7	0·37	1·63	2·0	9·2
8·5	5·3	4·4	1·7	1·35	7·0	5·80	2·6	11·1	0·65	2·49	3·2	13·7
9·5	5·7	4·6	2·0	1·53	7·7	6·15	3·2	12·5	0·84	2·93	4·0	15·7
10·5	6·0	4·6	2·1	1·55	8·1	6·23	3·9	14·1	0·87	2·77	4·7	17·1
11·5	6·1	4·5	1·6	1·14	7·7	5·73	4·5	15·1	0·57	1·65	5·1	17·1
12·5	6·1	4·4	1·7	1·17	7·8	5·62	5·1	15·7	0·68	1·80	5·8	17·9
13·5	5·9	4·1	3·2	2·15	9·1	6·35	4·7	12·9	1·71	4·16	6·4	17·6
Mean	5·62	4·53	1·83	1·39	7·46	5·99	3·42	13·7	0·67	2·20	4·09	15·5

Glasgow measurements

The Glasgow data shown in Figs. 3 and 4 have the advantage that the time span is more completely covered, and show the trend of the secular change over a period of 40 years. It will be noted that, whereas the trend is upwards throughout the period, the gradient has not been uniform. Little change took place till after the first World War and the subsequent economic depression. The yearly data (not shown) also suggest a deceleration during the depression in the early thirties. There was a marked increase in 1941. The reasons for this are complex. During the previous year a big exodus of schoolchildren took place from the city, followed by the return of most of the evacuees. Periods of evacuation would benefit many of the children. The increase is larger than could be accounted for by the evacuation of the more stunted children and omission of their measurements from the totals. In fact there was a greater frequency of sustained evacuation among older girls from secondary schools in certain better-class areas of the city and probably among the better pupils in other groups. Young (1942) summed up the position as follows: 'To what extent increased family incomes, the milk in schools scheme, the absence of major epidemics of infectious diseases and perhaps periods of evacuation have contributed to this result it is difficult to say.' For the next few years there was a lag in growth, especially in height, but by 1949 the measurements exceeded even the exceptional figures of 1941.

The assessment of growth

In assessing any change over a period of years the accuracy of the measurements must be considered. It is becoming appreciated nowadays that routine measurements of heights and weights are subject to appreciable errors of observation. The variance from this source, however, is small in comparison with the total variance. Systematic errors may arise from differences in the clothing conditions under which the measurements are made. All the data surveyed here, as far as can be ascertained, refer to 'indoor clothing without shoes'. In a small survey the number of individuals in each sample group is of critical importance and should always be recorded. Thus even in the 1949 London survey, based on measurements of 21,000 children, the standard errors of the age groups means approximate to 0·2 cm in height and from 0·09 to 0·25 kg in weight. Both these standard errors exceed the average secular yearly change.

A serious problem, curiously enough, is that of the age. Age is generally regarded as the independent variable and assumed to be accurate; but, apart from gross errors such as that of confusing central age and age last birthday (Elderton, 1914), it is usually subject to a sampling error. If the age last birthday at the time of measurement is used, then on an average the mean age of each group will be age last birthday plus 6 months. This expected difference of 6 months is associated with a standard error of $1/\sqrt{(12n)}$ years (where n is the number in the sample) which can if desired be converted into an equivalent error of height and weight. In practice it is convenient to classify the children according to year of birth rather than age last birthday, and the raw age groups are then year of observation less year of birth. The mean age of

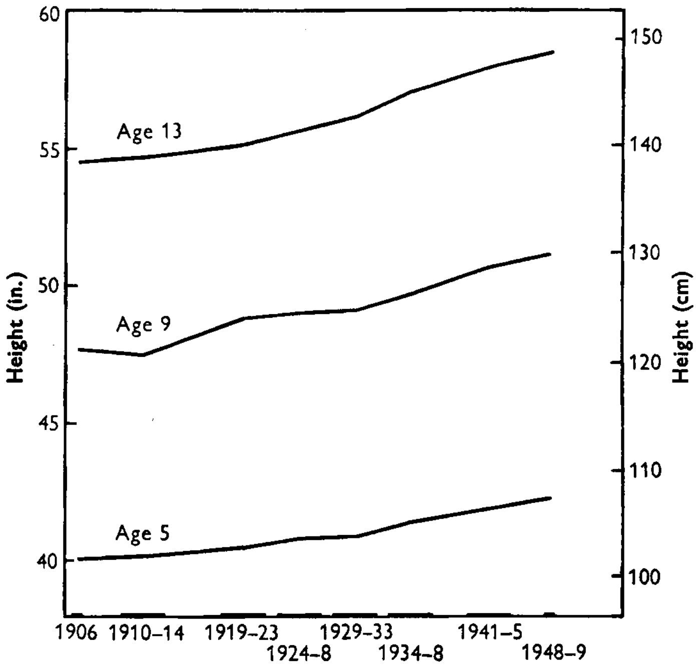

Fig. 3. Secular changes in growth of Glasgow schoolboys. Average values of height of age groups 5, 9 and 13 years for the periods indicated.

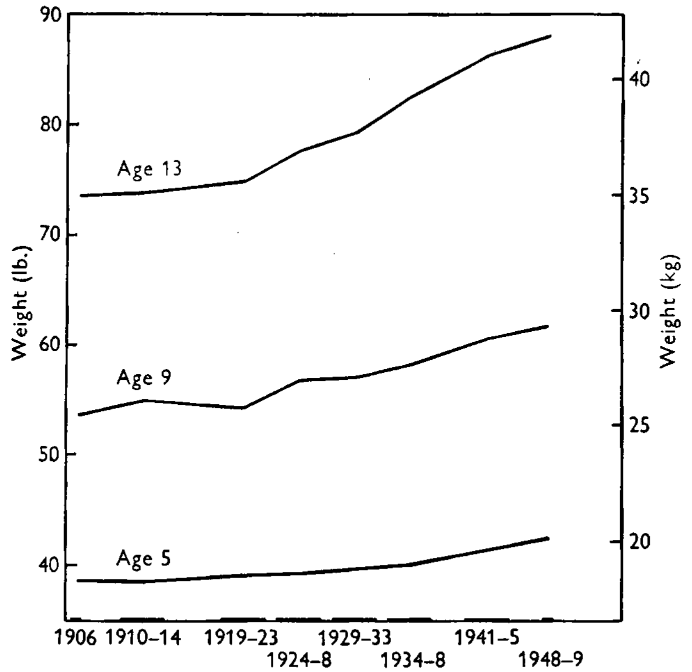

Fig. 4. Secular changes in growth of Glasgow schoolboys. Average values of weight of age groups 5, 9 and 13 years for the periods indicated.

each group will of course depend on the time of year at which the measurements are taken and is subject to the above sampling error with an additional sampling error in the mean date of measurement. There is thus an element of uncertainty as to the exact mean age of the various groups from different sources of data.

A further difficulty is that in presenting the measurements it is customary to adjust them to certain fixed ages. In the 1949 London data this was done by linear interpolation, whereas in the 1938 figures parabolic curves were fitted to the raw data, and heights and weights then calculated at 3-month intervals. In Glasgow the main age groups have standard central ages of 5 years 4 months, 9 years 5 months and 13 years 5 months. Adjustment to these is effected by using the regressions of height and weight on age. The estimates of these regressions have varied considerably.

The net result then is that the heights and weights at stated intervals obtained from a variety of sources covering a matter of 40 years are subject to appreciable errors which are probably mainly random and so would account for many of the deviations from smooth curves in the accompanying figures. Fortunately, the secular changes over a period of years are quite large in comparison with the total estimated error so that the main features are beyond doubt, but this lack of precision is a drawback in the more detailed analysis of the changes.

Reduction of data

Surveys of heights and weights produce very large numbers of figures and to compare one survey with another presents a difficult problem. An obvious step is to reduce the data to the means at each age group and then, as in Table 1, to compare the means in corresponding groups. A further step is to compare the averages over all the age groups, provided that they correspond, or at least that the mean age is the same. An example of the expression of the result in this form is that Glasgow boys were on the average 3·21 in. taller and 8·24 lb. heavier in 1949 than in 1910–14. What is the significance of these differences? The higher age groups contribute more to them than the lower groups; the regression of difference of height on age is probably curvilinear and that of weight on age definitely curvilinear. At the best it gives some kind of indication of the difference between an average child in the central age group of one survey and a similarly situated child in the other. The difference is less in the lower age groups and more in the higher. An improvement can be effected by using either the logarithms of the heights and weights or the percentage changes, but the method developed below is preferable.

Units of growth

The relationship between changes in height and simultaneous changes in weight can be studied directly; but it seemed that it would be illuminating and also more convenient to use the common link between height and weight, namely age, and to study the changes in terms, not of height and weight, but of a year's growth. Fig. 1 indicates that the secular change in growth, besides being regarded as an increase in the average height and weight of each age group, may equally well be considered as an earlier attainment of the same average measurement, in other words as more rapid growth. Fig. 5 shows the London 1938 smoothed weights plotted against the smoothed heights and provides a standard track or axis of growth. Any deviation from the track implies a difference of form or build from the standard. Now, when any of the other

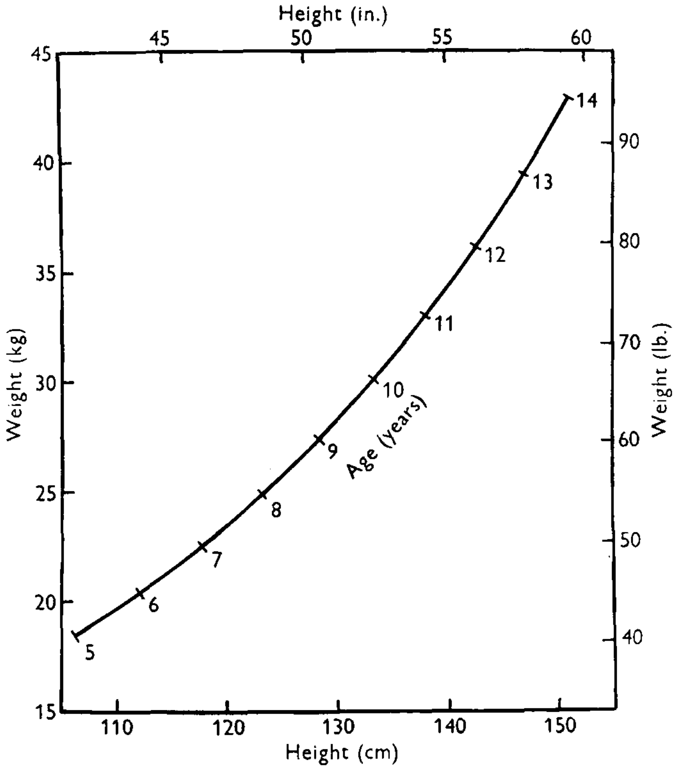

Fig. 5. Standard growth track. Relation of average height and weight of 1938 London schoolboys to age in years.

sets of average heights and weights are plotted on the same diagram it is found that the points lie very close to this standard track but are advanced or retarded with reference to the age scale. The main effect of the secular change is more rapid growth, and any change of form is subsidiary. In view, however, of the possibility of different effects on the rate of growth in height and weight it was decided to keep them separate and to use two units of growth, a year's growth in height and a year's growth in weight.

Ages for height and for weight—growth ages

A diagram on the lines of Fig. 5 is adequate for many comparisons, but to obtain greater precision parabolic curves were fitted by the method of least squares to the 1938 London data which give age in terms of height and age in terms of weight. Tables 2 and 3 were then drawn up. Table 2 gives the age to the nearest 0·01 year for each cm of height from 100 to 150 cm and mean differences for mm. Table 3 similarly gives ages corresponding to each 0·1 kg from 17 to 41 kg and mean differences for

0·01 of 1 kg. With the aid of the tables the age corresponding to any height or weight growth-age within the range is readily found, and comparison with the chronological age indicates at once the relative advancement or retardation in terms of year's growth.

Table 2. *Age in years corresponding to height in cm in boys (based on average heights of London boys: data of Menzies,* 1940)

eight cm)	cm										Mean differences for mm h						
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7
100	4·03	4·18	4·34	4·50	4·66	4·82	4·98	5·15	5·31	5·48	2	3	5	6	8	10	11
110	5·65	5·82	5·99	6·16	6·34	6·51	6·69	6·87	7·05	7·23	2	4	5	7	9	11	12
120	7·42	7·60	7·79	7·98	8·17	8·36	8·55	8·75	8·95	9·14	2	4	6	8	10	12	13
130	9·34	9·54	9·75	9·95	10·16	10·36	10·57	10·78	10·99	11·21	2	4	6	8	10	12	15
140	11·42	11·64	11·86	12·08	12·30	12·52	12·74	12·97	13·20	13·42	2	4	7	9	11	13	16
150	13·66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 3. *Age in years corresponding to weight in kg in boys (based on average weights of London boys: data of Menzies,* 1940)

eight kg)	0·1 kg										Mean differences for 0·01 kg						
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7
17	4·33	4·38	4·43	4·48	4·53	4·58	4·63	4·68	4·73	4·78	1	1	2	2	3	3	4
18	4·83	4·88	4·93	4·98	5·03	5·08	5·13	5·18	5·23	5·28	0	1	1	2	2	3	3
19	5·32	5·37	5·42	5·47	5·52	5·57	5·62	5·66	5·71	5·76	0	1	1	2	2	3	3
20	5·81	5·85	5·90	5·95	6·00	6·04	6·09	6·14	6·18	6·23	0	1	1	2	2	3	3
21	6·28	6·32	6·37	6·42	6·46	6·51	6·55	6·60	6·64	6·69	0	1	1	2	2	3	3
22	6·74	6·78	6·83	6·87	6·92	6·96	7·01	7·05	7·10	7·14	0	1	1	2	2	3	3
23	7·18	7·23	7·27	7·32	7·36	7·40	7·45	7·49	7·53	7·58	0	1	1	2	2	3	3
24	7·62	7·66	7·71	7·75	7·79	7·84	7·88	7·92	7·96	8·01	0	1	1	2	2	3	3
25	8·05	8·09	8·13	8·17	8·22	8·26	8·30	8·34	8·38	8·42	0	1	1	2	2	2	3
26	8·46	8·50	8·54	8·59	8·63	8·67	8·71	8·75	8·79	8·83	0	1	1	2	2	2	3
27	8·87	8·91	8·95	8·99	9·03	9·07	9·11	9·14	9·18	9·22	0	1	1	2	2	2	3
28	9·26	9·30	9·34	9·38	9·42	9·45	9·49	9·53	9·57	9·61	0	1	1	2	2	2	3
29	9·64	9·68	9·72	9·76	9·79	9·83	9·87	9·91	9·94	9·98	0	1	1	1	2	2	3
30	10·02	10·05	10·09	10·13	10·16	10·20	10·23	10·27	10·31	10·34	0	1	1	1	2	2	2
31	10·38	10·41	10·45	10·48	10·52	10·55	10·59	10·62	10·66	10·69	0	1	1	1	2	2	2
32	10·73	10·76	10·80	10·83	10·86	10·90	10·93	10·97	11·00	11·03	0	1	1	1	2	2	2
33	11·07	11·10	11·13	11·17	11·20	11·23	11·26	11·30	11·33	11·36	0	1	1	1	2	2	2
34	11·39	11·43	11·46	11·49	11·52	11·55	11·59	11·62	11·65	11·68	0	1	1	1	2	2	2
35	11·71	11·74	11·77	11·80	11·84	11·87	11·90	11·93	11·96	11·99	0	1	1	1	2	2	2
36	12·02	12·05	12·08	12·11	12·14	12·17	12·20	12·23	12·26	12·28	0	1	1	1	1	2	2
37	12·31	12·34	12·37	12·40	12·43	12·46	12·49	12·51	12·54	12·57	0	1	1	1	1	2	2
38	12·60	12·63	12·65	12·68	12·71	12·74	12·76	12·79	12·82	12·84	0	1	1	1	1	2	2
39	12·87	12·90	12·92	12·95	12·98	13·00	13·03	13·06	13·08	13·11	0	1	1	1	1	2	2
40	13·13	13·16	13·19	13·21	13·24	13·26	13·29	13·31	13·34	13·36	0	1	1	1	1	2	2
41	13·39	13·41	13·43	13·46	13·48	13·51	13·53	13·56	13·58	13·60	0	0	1	1	1	1	2

It should be noted that the tables give the age at which the London boys attained given average heights and weights, and do not necessarily represent the average age of attaining a given height and weight. There is no longer any necessity to adjust measurements to fixed ages before they can be compared. The tables can also be used inversely to give the standard height and weight corresponding to a given age. The values so found do not differ significantly from the regressions of height and of weight on age obtained directly. The use of the tables is not confined to comparisons with the

London 1938 averages since they can be used simply as a yardstick to compare two or more individuals or groups.

Relation of growth age to chronological age

A matter of some importance is the relation of growth age to age or of advancement or retardation to age. Menzies (1940) comparing London children in 1938 with those in 1905–12 finds that the advancement is approximately constant at 1 year's growth. However, when the deviations of each set of data from the standard are examined it is evident that they are progressive with age. The trend is quite clear when the

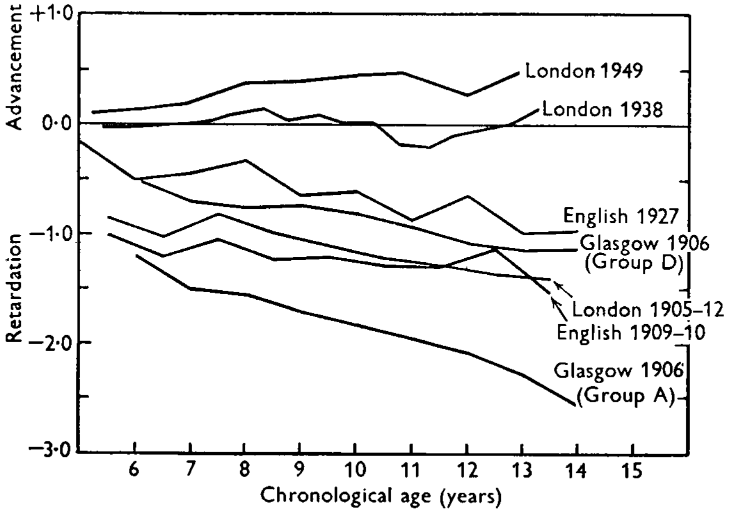

Fig. 6. Relation of relative advancement or retardation of growth in height (height age less chronological age) to chronological age. The retardations or advancements are progressive and approximately proportional to age. Glasgow 1906 (group A) poorest districts, Glasgow 1906 (group D) better class districts.

deviations are plotted against age as in Fig. 6. All the sets of data show some degree of irregularity, but the regressions show no consistent deviation from linearity. In some instances the points agree best with a straight line which meets the age axis somewhat to the negative side of the origin, but on the whole for the range studied all agree reasonably well with straight lines through the origin, and this is a great practical advantage. On this basis the secular change may be regarded as a uniform decrease in the scale factor, for time and growth age may be regarded as directly proportional to chronological age. The deviations of the points from straight lines—residual error—are partly due to the sampling and other errors already discussed and partly to irregularities in the secular change itself and to imperfections in the standard. The secular change has varied from time to time with wars, depressions and similar causes. It will be appreciated that the physique of the 5-year-old children is an index of conditions over the previous 5 years, that of the 10-year-old children an index of the previous 10 years and so on. Thus what is compared is one composite group of years with another similar group some years later, and variations in the secular change will affect the different age groups to different extents.

Growth-rate indices

When the age for height and age for weight, whether of an individual or of an age group, are expressed as percentages of the chronological age they give the growth rate as a percentage of the standard growth rate and so form convenient indices of growth, which will be called the growth rate in height and the growth rate in weight. In so far as the growth ages are proportional to chronological ages the indices are independent of age. This is confirmed by actual calculation, though in some instances in which the indices are less than 100 they increase slightly with age.

Estimate of group indices

The comparison of the growth of groups of children of various ages is greatly simplified by the use of a growth-rate in height index and a growth-rate in weight index for each group. These group indices are essentially weighted means of the individual or subgroup indices. Assuming that the growth ages within each group, apart from random variations, are proportional to the chronological ages, the calculation of a group index is equivalent to that of finding the gradient of the 'best' straight line through the origin in the plot of growth age against chronological age. There is a choice of three methods. Let x years be the chronological age, y years the growth age (in height or weight), b the gradient or group index and n the number of points. Then:

(1) Group index $= b = \dfrac{\Sigma(y/x)}{n}$ or mean value of y/x;

(2) $b = \Sigma y/\Sigma x$; hence the group index = mean growth age divided by mean chronological age;

(3) $b = \Sigma xy/\Sigma x^2$.

With the data examined the differences in the results by the three methods are not significant. The second method is the simplest when only the index is required and is the method used for the results given in Table 4 and plotted in Fig. 9. Ideally the method yielding the minimum variance should be chosen, but simplicity of calculation may be more important.

Chronological age multiplied by the group index gives the regression of growth age on chronological age or the expected growth age for each member of the group.

Combination of growth curves

Any set of data forming the basis of a growth curve is subject to sampling and other errors. The question therefore arises: can several sets of data, e.g. the three sets of average weights shown in Fig. 2, be combined to give a more reliable and representative curve? To do this the secular change or other difference of a similar nature must be eliminated. In Fig. 7 the same data as in Fig. 2 have been plotted against expected growth age instead of against chronological age. All three sets of data now agree satisfactorily with each other thus affording a neat confirmation of the validity of the assumption of proportionality of growth age and chronological age. A cubic parabola might give a slightly better fit at the extremes, but the curve shown (simple parabola) which was fitted to the 1938 data appears to be adequate for this range.

Secular change and social conditions

The secular change in growth is very similar to the variations that are associated with differences in social conditions. Table 4 gives the growth-rate indices corresponding to all the data dealt with here. It will be noticed that the secular change over

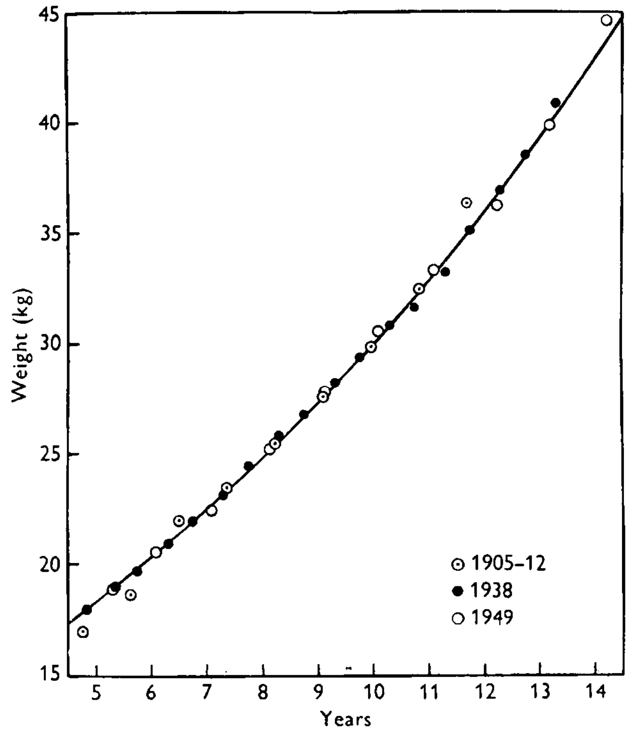

Fig. 7. Combination of growth curves. Average weights of London schoolboys in 1905–12, 1938 and 1949 plotted against *expected growth ages*, i.e. age × 0·866 for 1905–12 group, age × 1·0 for 1938 group and age × 1·0215 for the 1949 group. The curve was fitted to the 1938 values. Compare with Fig. 2.

Table 4. *Growth-rate indices of height and weight of London, English and Glasgow boys (estimated by method 2, p. 28) for the years and social groups indicated. The* 1938 *London average is taken as the standard and is* 100 *for both indices*

	London		English		Glasgow				Glasgow 1906 groups			
ndex	1905–12	1949	1909–10	1927	1910–14	1927	1938	1949	A	B	C	D
ight	88·3	103·9	87·6	93·6	82·0	89·1	93·8	99·1	81·5	84·6	87·3	91·
eight	86·6	102·2	86·2	89·7	84·5	88·7	93·7	98·5	83·5	86·1	88·3	90·

a period of some 40 years has considerably exceeded the range of the 1906 Glasgow groups. The comparison is elaborated in the Glasgow report for 1944 (Young, 1945) which gives the average heights and weights of the standard age groups classified according to the number of apartments* in the house. The heights and weights of the schoolchildren increase with the number of apartments; in all groups there are increases from 1906 to 1944; the increases are greatest for the single apartments. In

* 'Apartments' as given here is equivalent to the English usage of 'rooms'.

the 5-year age group the single-apartment figures for 1944 are comparable with the best 1906 figures. In the 9-year age group the 1944 figures for single apartments are considerably better than the best 1906 figures. The 13-year age group similarly shows a superiority over the best 1924 figures.

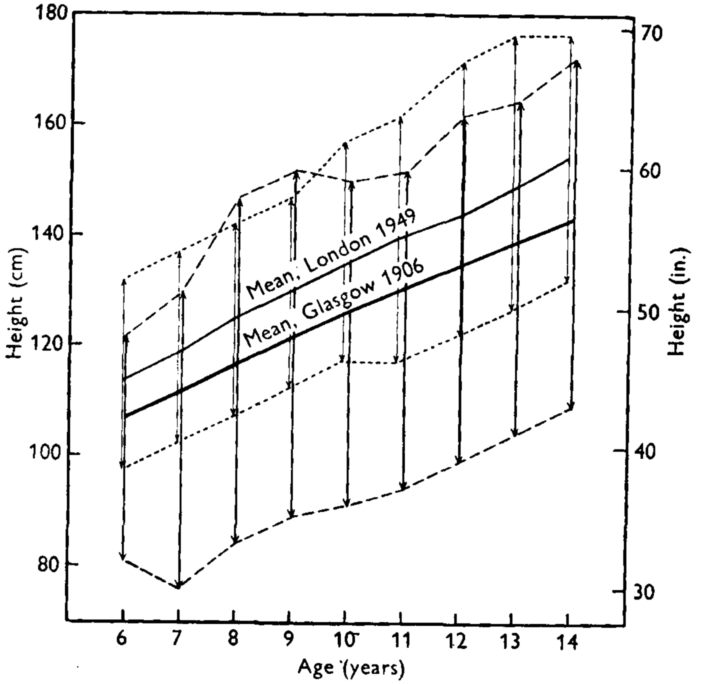

Fig. 8. Mean values and ranges for height of London boys in 1949 and Glasgow boys in 1906. Note the marked difference in the lower limit and little difference in the upper limit.

Secular change in relation to total variability of school population

So far only average values of height and weight have been considered. It is interesting to compare the secular change in growth with the variability of the school population at one time. The 1949 London report gives the standard deviations of both heights and weights. The secular change in London boys over a period of 40 years is almost identical with the standard deviation for weight and slightly in excess of it for height. The means and ranges of the heights of Glasgow boys in 1906 and London boys in 1949 are compared in Fig. 8. Despite the considerable difference between the mean figures, the 1949 London mean lags still further behind the Glasgow 1906 upper limit. The Glasgow range, which has been modified to allow for the fact that the Glasgow sample was larger than the London sample, is much larger than the London range. The Glasgow distribution is markedly skew, whereas the London one is fairly symmetrical. These facts suggest that the secular change reduces the scatter by relatively greater changes in those who are most retarded. This is confirmed by the relatively greater improvement in the Glasgow children from one-apartment houses compared with those better circumstanced.

Growth indices and body build

The growth-rate indices of height and weight provide a convenient way of studying body proportions or build both in individuals and in groups. If the two indices are equal then, whether growth is advanced or retarded, it is along the standard track and the build, so far as it is determined by height and weight, corresponds to the 1938

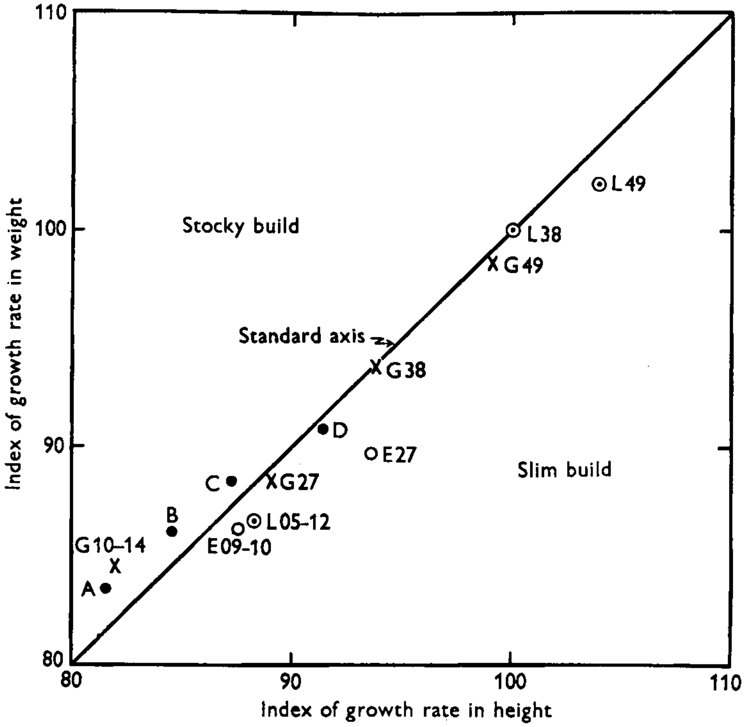

Fig. 9. Growth-rate indices of height and weight and the standard axis along which they are equal. The growth rate of London boys in 1938 is taken as the standard and is 100 on both scales. Deviations from the axis indicate a difference of body build. L 05–12, L 38, L 49 = London boys in 1905–12, 1938 and 1949; G 10–14, G 27, G 38, G 49 = Glasgow boys in 1910–14, 1927, 1938 and 1949; A, B, C, D, school groups in Glasgow in 1906; E 09–10, E 27, English boys in 1909–10 and 1927.

London standard. A weight index greater than the corresponding height index implies a stocky build and the converse indicates a slim build. The range of difference between the weight index and the height index of individuals is about ± 30, e.g. among boys aged 10 years of average height (height index 100) some weigh as much as an average boy of 13 years and some as little as an average boy of 7 years (weight indices 130 and 70 respectively).

Fig. 9 shows the group growth-rate indices of height and weight for London, Glasgow and English schoolboys in relation to the standard axis. It demonstrates the marked advance during this century and also illustrates the fact that despite the marked changes in rate of growth (or of height and weight at a given age) the changes in build are extremely small in comparison with the range in the school population. This applies to all the age groups, not merely to the means. A rather fine point that may also be noticed is that with more rapid growth there is on the whole a tendency to a slimmer build, an oblique movement across the axis from left to right. The movement from London 1905–12 to London 1938 is an exception possibly due to sampling errors. It has been suggested that the oblique movement is due to a decreased incidence of rachitic deformity, but that is only a contributory cause. The figures for the London health divisions between 1938 and 1949 show that the north-east division crossed the line from left to right and the south-west division, which was already to the right in 1938, moved still further out.

In so far as the Glasgow 1906 groups are evidence of differences of nutrition they show that the dominant effect of undernutrition is retardation of growth and that an increased weight over that expected from age and height is not a reliable criterion of good nutrition. As to the cause of the secular change itself the only plausible explanation is a gradual improvement in nutrition.

DISCUSSION

To regard the secular change in growth merely as an increase of height and weight or even as a percentage increase in these measurements is misleading; e.g. Daley (1950) states that children of to-day are members of a generation altogether of greater physique. Now, neither the absolute nor the percentage increases in height are maintained into adult life. It is at present debatable whether or not there is any secular increase in the mean adult maximum height attained (Morant, 1948, 1950; Kemsley, 1950); but, if there is, it is certainly much less than the 3–4 in. of absolute increase or 6 % or so of percentage increase that has taken place in children during the past 40 years. On the other hand, to regard the change as an acceleration of the rate of growth is in agreement with the observed earlier attainment of maximum height; it does not preclude a secular increase in that height, and some increase seems likely with the elimination of retarded growth during childhood. The slow growers compensate to some extent by growing longer. This follows from the fact that the standard deviation of height reaches a maximum about the age of puberty and then declines. Growth and nutrition are intimately related and rate of growth is an index of nutrition. It may well be that the growth-rate indices will prove of value in assessing the nutrition of a group of schoolchildren, though there are too many other factors involved for them to be of much use with one individual.

SUMMARY

1. Published data of heights and weights of schoolboys in London and Glasgow during the present century have been examined and compared graphically and analytically.

2. In some 40 years the average height of London schoolboys has increased by about 7·5 cm (3 in.) and the average weight by about 4 kg (9 lb.). The Glasgow figures are similar.

3. The problem of comparing surveys of heights and weights is discussed.

4. Two units have been introduced, a year's growth in height and a year's growth in weight.

5. These lead to the concept of a growth age, and tables based on 1938 London averages are given for age corresponding to height and age corresponding to weight.

6. Growth ages in height and weight are proportional to chronological age.

7. The ratios give two indices of growth, growth rate in height and growth rate in weight.

8. Special methods are given for evaluating the growth indices of groups of children.

9. Secular changes in growth are similar to the differences in growth associated with differences in social conditions.

10. The secular change in 40 years approximated to one standard deviation of the measurements of the 1949 London boys.

11. The difference of the two indices is an index of body build.

12. The principal conclusion is that schoolchildren of to-day are growing faster than children of previous generations. As a result of the accelerated growth adult stature is earlier attained but not necessarily increased.

13. The indices of growth may be of value as indices of nutrition.

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