AN ANTHROPOMETRIC STUDY OF EDINBURGH SCHOOLCHILDREN

PART I. METHODS, DATA AND ASSESSMENT OF MATURITY

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The present study represents one part of a joint investigation of a stratified sample of Edinburgh schoolchildren carried out in collaboration with J. N. Mansbridge (who was investigating dentition and dental caries in the same sample) and with the statistical help of Dr. L. Stein and staff of the Department of Social Medicine, University of Edinburgh. The purpose of the anthropometric study was to provide, in the first instance, cross-sectional data which could be used for comparison with similar measurements on other groups of Edinburgh children (e.g., premature babies, mental defectives and others), for comparing children in this city with other geographical populations and for subsequent use in studies of secular changes in the growth of schoolchildren over a period of years. The lack of recent Scottish data for any measurements other than those of height and weight, and the incompleteness even of such data over the whole age-range 5 to 18 years, was an additional reason for undertaking the survey. Clinical assessment of maturity was included in the investigation in order to provide data on age-onset of puberty in both sexes, for which no recent Scottish figures are available. The methods of sampling, techniques of measurement and statistical treatment are outlined, and the basis of classification of the children into maturity groups is indicated. All maturity-grading and measurements, except where otherwise stated, were carried out by one of us (H.S.P.). The basic data which are now presented will be discussed more fully, together with the frequency distributions of length and weight in a subsequent paper (Part II).

Methods

Sample. It was desired to obtain as good a sample as possible of the day pupils in the city between the ages of 5 and 18 years: the planning and stratification of the sample was undertaken by the statistical section of the Department of Social Medicine. Ages were reckoned

from the date of birth to the date of examination. Since socio-economic factors often influence growth, the children were divided into two groups: those attending local authority schools (non-fee-paying) and those attending private schools (fee-paying). The children were placed in age groups and the proportions of non-fee-paying and fee-paying were dictated by the proportion of schoolchildren in the appropriate group being educated in those types of school in Edinburgh during 1951. The percentages of boys from fee-paying schools in the investigation in each year-age group were approximately 13 from 5 to 11 years, 15 from 11 to 14 years, 18 from 14 to 15 years, and 44, 52 and 56 at 15+, 16+ and 17+ years respectively. The corresponding figures for girls were approximately 12% from 5 to 11 years, 14% at 11 to 13 years, 12% at 13 to 15 years, and 31, 43 and 44% at 15+, 16+ and 17+ years respectively. The research was made on 1,730 pupils, there being rather more boys than girls. The data for the two sexes were recorded separately.

It was decided to select a few schools with large numbers of pupils extending over a wide age range to save unnecessary disruption of educational programmes, time and labour. Practical considerations prevented undertaking a theoretically more scientific approach. The subjects were drawn from nine schools; five were local authority and four fee-paying. The city School Medical Officer initially chose two primary (mixed) and two secondary (mixed) schools, care being taken to exclude those of a special character, e.g., of a religious persuasion. The schools were divided into age groups and the required sample taken by random number. Sufficient numbers of non-fee-paying subjects in the 5-14-year-old age groups were obtained in this way and the sample was entirely random. Another secondary school was later required to make up the children in the 15-17-year-old age groups to an adequate number. Selection in this school was also initially by random number, but the sample is biased, particularly in the 16-17-year-old age groups, as, owing to the small numbers available, little selection was possible and most or all had to be included.

The fee-paying schools included two boys' schools and two girls' schools. The fees in all were substantial.

There were so few schools which fulfilled the criteria laid down that those which were able to cooperate in the investigation were used. Owing to the small numbers of fee-paying pupils required in the 5-14-year-old age groups individuals to be measured were not chosen at random, but by taking every third child in the age group series. The same general procedure was adopted for the older age groups, but shortages in the numbers available often made any selection procedure impracticable.

The great majority of the measurements were made during the autumn and spring terms 1951-52, but owing to difficulties in obtaining adequate samples of the older age groups, the investigation was not completed until 1953.

Measurement. Nine body measurements were taken on each child. They consisted of recumbent supine length, i.e., crown-heel length, crown-rump length (stem-length), and span; bi-acromial diameter and intraspinal pelvic width; weight; and the circumference, length and breadth of the head.

THE LINEAR BODY MEASUREMENTS. These were the first three listed above. The children wore vest and pants, knickers or shorts. Most of the readings were taken by H.S.P. and the remainder by J. N. Mansbridge.

RECUMBENT CROWN-HEEL LENGTH. This was measured by means of a simple apparatus consisting of a broad 6½-ft. wooden base with a fixed vertical board at one end and a sliding vertical board at the other which moved up a central slot. A scale graduated in feet and inches was inlaid. The accuracy of the scale was checked. The apparatus was made portable by hinging it in the middle of its length. The child lay down supine and straight in the machine. The head in the standard position (i.e., with the Frankfort plane vertical and the bi-aucular plane horizontal) was rested firmly against the fixed head-piece: the feet were placed together and dorsiflexed and the sliding board pushed up against the two heels after which the soles were allowed to fall comfortably into position against the vertical foot-piece which was screwed down. Readings were taken to the nearest one-eighth of an inch. It was found in practice that the commonest errors in position which had to be avoided were: the head not being firmly in position against the board, the head being moved to one side, or the neck being flexed excessively. Much more rarely the child did not lie straight.

CROWN-RUMP (STEM) LENGTH. This was also measured by the apparatus described. The position taken up by the child was similar to that for recumbent length. The legs were then flexed so that the thighs were at right angles to the trunk with the knees flexed. The sliding board was moved up and pressed firmly against the buttocks and the distance between the ischial tuberosities and the vertex of the head noted in the same way as for crown-heel length.

SPAN. The same apparatus was used to measure the span. This was recorded as the distance between the tips of the middle fingers of each hand with the arms abducted at a right angle to the body. The child lay down on the back with the body and arms in the general

position indicated in such a way that the span came to lie centrally along the measuring board. The forearms were fully pronated with palm downwards and fingers together and in the extended position. The measurement was recorded to the nearest one-eighth of an inch.

MEASUREMENT OF BODY MASS: WEIGHT. All weighing machines were checked for accuracy before use. In the local authority schools modern lever type machines manufactured by Avery were provided. Weights were recorded to the nearest ¼ lb. The private schools varied. One boys' school and one girls' school had lever balances of an older type, recording weights to the nearest ¼ lb. The other two schools had no weighing machine. A portable 'waymaster' spring balance was used and errors from the true weight corrected. Recording of data to the nearest pound was the greatest accuracy obtainable in these schools. The nude weights of the children are given. The younger children were weighed without clothes. Those who were maturing sexually were given a surgical gown to cover themselves and the weight of the gown subtracted from the recorded weight. The great majority of the readings on the Avery machines were taken by J. N. Mansbridge and those on the 'waymaster' by H.S.P.

MEASUREMENTS OF BODY WIDTH. Two were taken, i.e., bi-acromial diameter and intraspinal pelvic width. A Collin's pelvimeter was used and data recorded to the nearest half centimetre.

Bi-acromial Diameter. The child removed the vest unless it was of such a type that the acromial processes were exposed and palpable. The standing position was adopted with the arms by the side, care being taken that the shoulders were neither raised nor projected anteriorly. The examiner stood behind the subject. Holding the pelvimeter parallel with the ground, the tips of the blades were pressed firmly downwards and medially against the acromion processes. In practice a definite niche between the head of the humerus and acromial process of the scapula was found.

Pelvic Width. The child assumed the erect position with the feet together. The examiner stood in front, and having exposed the hips, laid the points of the pelvimeter on the outer aspects of the anterior superior iliac spines of the ilium. The instrument was held so that it was parallel with the ground.

MEASUREMENT OF THE HEAD. Three measurements were taken, namely, circumference, head length and head breadth. With the girls it was often necessary to remove clasps, kirby grips, ribbons, hair nets, undo plaits and re-distribute the hair so that it lay evenly. The children were seated. The measurement was recorded to the nearest half centimetre.

Circumference. A thin flexible steel tape was employed and the observations taken from the front. The surface markings used were the external occipital protuberance and the glabella.

Head Length. The subject looked to the front and the examiner stood at the side. One tip of the pelvimeter blade was placed on the glabella and the other swept to and fro over the external occipital protuberance in the

antero-posterior axis. The maximum reading was taken.

Head Breadth. With the subject in the same position the examiner moved round facing him, placing the two points of the calipers above the ears, i.e., just above the external auditory meatus. The calipers were moved vertically upwards and downwards to and from the vertex, and the maximum reading recorded.

Estimation of Maturity. Both sexes were graded in three clinical groups: 'non-pubescent' showing no signs of sexual development, 'adolescent' showing an advanced degree of maturity and the 'intermediate pubescent' sexually-developing group. The classification of the boys was determined by the criteria laid down by Ellis (1946). The onset of pubescence in the girls was taken to be breast enlargement, the earliest sign noted being

vascularization and enlargement of nipple and areola. Since this normally precedes the appearance of pubic hair by approximately a year, it provides a reasonably reliable landmark without subjecting children to more detailed examination. 'Adolescence' was reached at the onset of menstruation.

Results

Much of the work of compiling and analysing the results was done by the statistical section of the Department of Social Medicine.

Tables 1 and 2 present the statistical findings of the anthropometric study described in year-age groups from 5 to 18 in the two sexes. The numbers of children measured in each age group are given, together with the central age of the group. Three

STRATIFIED SAMPLE OF ENGLAND

Year Age Group	No.	Statistic	Age (years)	Length (cm.)	Crown-Rump (cm.)	Span (cm.)	Crown-Rump Length Ratio
5+	56	Mean S.D. C.V.	5.51 0.256 0.046	109.3 4.90 0.045	62.6 2.97 0.048	107.2 5.45 0.051	0.573 — —
6+	67	Mean S.D. C.V.	6.50 0.282 0.043	115.4 6.15 0.053	64.9 3.03 0.047	114.3 6.82 0.060	0.564 — —
7+	55	Mean S.D. C.V.	7.59 0.263 0.035	122.1 5.85 0.048	67.5 2.90 0.043	121.6 5.98 0.049	0.558 — —
8+	63	Mean S.D. C.V.	8.46 0.294 0.035	125.2 5.12 0.041	68.5 2.73 0.040	125.2 5.45 0.044	0.548 — —
9+	60	Mean S.D. C.V.	9.51 0.326 0.034	130.5 5.92 0.045	70.8 2.59 0.037	130.5 5.99 0.046	0.543 — —
10+	63	Mean S.D. C.V.	10.51 0.269 0.026	136.0 6.07 0.045	72.8 2.54 0.035	135.9 7.16 0.053	0.540 — —
11+	60	Mean S.D. C.V.	11.60 0.266 0.023	141.3 6.66 0.047	75.3 3.41 0.045	141.5 6.86 0.048	0.533 — —
12+	80	Mean S.D. C.V.	12.57 0.283 0.023	148.1 7.94 0.054	77.8 3.65 0.047	148.3 7.76 0.052	0.526 — —
13+	85	Mean S.D. C.V.	13.47 0.284 0.021	152.5 8.81 0.058	79.9 4.14 0.052	153.5 9.70 0.063	0.526 — —
14+	84	Mean S.D. C.V.	14.54 0.291 0.020	159.4 9.09 0.057	83.3 4.64 0.056	160.7 9.62 0.060	0.524 — —
15+	93	Mean S.D. C.V.	15.40 0.300 0.019	167.2 8.70 0.052	87.7 4.99 0.057	168.3 11.52 0.068	0.525 — —
16+	69	Mean S.D. C.V.	16.57 0.300 0.018	173.5 8.31 0.048	91.6 4.68 0.051	176.3 8.94 0.051	0.528 — —
17+	61	Mean S.D. C.V.	17.47 0.303 0.017	173.7 6.88 0.040	92.4 3.63 0.039	176.7 6.95 0.039	0.532 — —

S.D. = Standard deviation from mean.

ratios are included in the table, i.e., crown-rump length/length, span/length and head breadth/head length (cephalic index). Figs. 1 to 4 show graphically the means of three linear measurements (length, stem-length and span) and two measurements of width (bi-acromial diameter and intraspinous pelvic width) for the two sexes.

Comment

Length. In the present study, supine crown-heel length was measured in preference to erect height for two reasons. The first was that recumbent length measurements are essential in infants and that correct positioning for measurement of erect height

in toddlers and pre-school children is even more difficult than for recumbent length. In order to provide a continuous series of measurements from birth to maturity, it is desirable that all should be obtained in the same way. Secondly, it has been shown (Palmer, 1932) that posture is likely to affect measurements of erect height to a greater extent in girls than boys, particularly in the case of adolescents. It cannot be claimed that the recumbent position altogether eliminates the errors introduced by measuring erect height at different times of day, since diurnal variations are also substantial in measurements of recumbent length (Kelly, Sonders, Johnston, Bound, Hunscher and Macy, 1943). It can reasonably be assumed, however, that these

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BURGH SCHOOL CHILDREN, 1951/53
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Span/Length Ratio	Weight (kg.)	Bi-acromial Diameter (cm.)	Pelvic Width (cm.)	Head Circumference (cm.)	Head Length (cm.)	Head Breadth (cm.)	Cephalic Index
0.980 — —	19.01 2.10 0.110	24.47 1.15 0.05	18.42 1.07 0.06	51.15 1.42 0.03	17.77 0.603 0.03	13.87 0.518 0.04	0.781 — —
0.991 — —	21.05 2.82 0.134	25.66 1.47 0.06	19.04 1.11 0.06	51.83 1.24 0.02	17.93 0.647 0.04	14.06 0.457 0.03	0.786 — —
0.996 — —	23.83 2.64 0.111	26.75 1.09 0.04	19.92 1.17 0.06	52.19 1.28 0.02	18.12 0.577 0.03	14.18 0.434 0.03	0.783 — —
1.000 — —	25.23 2.83 0.112	27.66 1.17 0.04	20.75 1.08 0.05	52.37 1.39 0.03	18.14 0.625 0.03	14.23 0.490 0.03	0.785 — —
1.001 — —	27.50 3.27 0.119	28.44 1.45 0.05	20.99 1.15 0.05	52.69 1.26 0.02	18.19 0.576 0.03	14.35 0.425 0.03	0.789 — —
1.007 — —	30.25 3.84 0.127	29.40 1.58 0.05	21.98 1.14 0.05	52.97 1.52 0.03	18.39 0.638 0.03	14.41 0.528 0.04	0.785 — —
1.002 — —	33.42 5.06 0.151	30.46 1.85 0.06	22.74 1.37 0.06	53.42 1.23 0.02	18.41 0.635 0.03	14.57 0.500 0.03	0.793 — —
1.003 — —	37.04 5.62 0.152	31.45 1.81 0.06	23.63 1.52 0.06	53.89 1.38 0.03	18.60 0.643 0.03	14.59 0.516 0.04	0.785 — —
1.007 — —	41.96 7.85 0.187	32.86 2.18 0.07	24.38 1.76 0.07	54.13 1.37 0.03	18.65 0.676 0.04	14.78 0.472 0.03	0.793 — —
1.009 — —	45.98 7.82 0.170	34.17 2.45 0.07	25.48 1.78 0.07	54.58 1.53 0.03	18.77 0.637 0.03	14.87 0.521 0.04	0.792 — —
1.011 — —	54.57 8.89 0.163	36.27 2.47 0.07	26.73 1.61 0.06	55.61 1.77 0.03	19.21 0.825 0.04	14.95 0.664 0.04	0.779 — —
1.017 — —	60.57 8.35 0.138	37.94 1.99 0.06	27.64 1.59 0.06	56.56 1.34 0.02	19.45 0.642 0.03	15.28 0.585 0.04	0.786 — —
1.019 — —	62.46 9.70 0.155	38.30 1.87 0.05	27.89 1.26 0.05	56.62 1.50 0.03	19.57 0.692 0.04	15.43 0.670 0.04	0.790 — —

C.V. = Coefficient of variation.

variations, which are at least partly due to fatigue and posture, will be reduced by measuring length in the recumbent position. Comparisons between stem-length and crown-heel length will only be valid when both are taken in the same position (i.e., recumbent or erect), and again accurate positioning for stem-length is more readily achieved in children in the recumbent than in the erect position.

The use of recumbent length does, however, introduce a discrepancy when comparing data obtained by this method with other series in which erect height has been measured. Boyd (1929) found that supine length was 1 to 1½ cm. greater than erect height in children aged 2 to 5 years, and Palmer

(1932) made a detailed comparison of the relationship of the two measurements in older children, constructing conversion tables for each sex, which give the calculated erect height for any given value of supine length from 80 to 180 cm. For supine length 110 cm., erect height was found to be 1.0 cm. less in the case of boys and 1.05 less in the case of girls. Over the range 111 cm. to 180 cm. supine length, the mean differences from erect height were found to be 0.5 cm. (boys) and 1.1 cm. (girls). In practice, subtraction of these amounts from supine length will give an approximate value for erect height which will lie within the experimental error of routine measurements of height, but for

TABLE 2
STRATIFIED SAMPLE OF ENGLISH GIRLS

Year Age Group	No.	Statistic	Age (years)	Length (cm.)	Crown-Rump (cm.)	Span (cm.)	Crown-Rump Length Ratio
5+	48	Mean S.D. C.V.	5.60 0.237 0.042	110.4 4.99 0.045	62.5 2.50 0.040	107.6 5.34 0.050	0.568 — —
6+	61	Mean S.D. C.V.	6.54 0.263 0.040	115.6 5.97 0.052	64.5 2.92 0.045	113.7 6.66 0.059	0.559 — —
7+	58	Mean S.D. C.V.	7.49 0.281 0.038	121.1 5.18 0.043	66.9 2.65 0.040	119.4 5.42 0.045	0.553 — —
8+	57	Mean S.D. C.V.	8.49 0.287 0.034	125.4 6.30 0.050	68.8 3.15 0.046	123.4 6.20 0.050	0.550 — —
9+	56	Mean S.D. C.V.	9.51 0.294 0.031	130.2 6.13 0.047	70.3 2.89 0.041	129.7 6.91 0.053	0.541 — —
10+	63	Mean S.D. C.V.	10.48 0.253 0.024	135.4 7.18 0.053	72.6 3.41 0.047	134.8 7.27 0.054	0.538 — —
11+	64	Mean S.D. C.V.	11.52 0.289 0.025	141.4 7.11 0.050	75.5 3.41 0.045	141.2 7.40 0.052	0.535 — —
12+	79	Mean S.D. C.V.	12.54 0.296 0.024	148.4 7.18 0.048	79.2 3.73 0.047	148.3 7.95 0.054	0.534 — —
13+	75	Mean S.D. C.V.	13.49 0.299 0.022	155.1 7.43 0.048	83.3 4.43 0.053	155.5 8.30 0.053	0.538 — —
14+	62	Mean S.D. C.V.	14.51 0.302 0.021	157.1 7.47 0.048	84.6 4.05 0.048	157.9 7.61 0.048	0.540 — —
15+	86	Mean S.D. C.V.	15.40 0.307 0.020	162.1 5.30 0.033	87.7 3.19 0.036	163.2 5.69 0.035	0.541 — —
16+	69	Mean S.D. C.V.	16.48 0.265 0.016	162.8 5.33 0.033	87.8 2.89 0.033	164.6 5.45 0.033	0.540 — —
17+	56	Mean S.D. C.V.	17.46 0.305 0.017	164.3 6.66 0.041	89.9 3.28 0.037	164.4 6.65 0.040	0.548 — —

S.D. = Standard deviation from the mean

more accurate assessment Palmer's conversion tables should be used.

In most recorded data on children's heights and weights it has been found that these measurements of girls are less than those of boys at all ages except for a period lasting approximately from 11½ to 13½ or 14½ years; during this time the earlier age-onset of puberty causes girls to grow more rapidly and equal or exceed boys in height and weight. In the later teen-ages, growth in height of girls decelerates rapidly and their stature is again exceeded by that of boys. In the present series, it will be seen that the mean length of girls equals or exceeds that of boys between the ages of 11 and 14 years, and that from

14 to 18 years boys are significantly taller and from 15 to 18 significantly heavier. The present figures, however, do not demonstrate a consistent sex-difference in recumbent length in the younger age groups, though with the exception of one group (aged 9>10 years) the mean weight of boys is greater than that of girls from 5 to 11 years, and the means for stem-length and span tend to be slightly (but not consistently) greater. It should be emphasized that the sex-differences in average erect height observed in other series of younger children are often very small, e.g., 0·6 to 1·1 cm. in London schoolchildren 5 to 11 years (Daley, 1950), and measurement of recumbent length appears to

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Span/Length Ratio	Weight (kg.)	Bi-acromial Diameter (cm.)	Pelvic Width (cm.)	Head Circumference (cm.)	Head Length (cm.)	Head Breadth (cm.)	Cephalic Index
0·974	18·90	24·72	18·14	50·50	17·29	13·70	0·792
—	2·19	1·26	1·04	1·34	0·609	0·48	—
—	0·116	0·05	0·06	0·03	0·04	0·04	—
0·984	20·84	25·66	18·89	51·25	17·59	13·73	0·781
—	3·53	1·48	1·17	1·54	0·668	0·545	—
—	0·169	0·06	0·06	0·03	0·04	0·04	—
0·987	23·25	26·81	19·87	51·57	17·76	13·97	0·788
—	3·17	1·40	1·17	1·34	0·579	0·467	—
—	0·136	0·05	0·06	0·03	0·03	0·03	—
0·985	24·76	27·27	20·38	51·52	17·78	13·95	0·785
—	3·12	1·27	1·06	1·23	0·575	0·460	—
—	0·126	0·05	0·05	0·02	0·03	0·03	—
0·997	27·85	28·53	21·06	52·13	17·90	14·06	0·787
—	4·28	1·70	1·29	1·20	0·636	0·448	—
—	0·154	0·06	0·06	0·02	0·04	0·03	—
0·997	29·59	29·25	21·70	52·23	17·80	14·11	0·793
—	4·21	1·60	1·30	1·38	0·657	0·470	—
—	0·142	0·05	0·06	0·03	0·04	0·03	—
0·999	33·84	30·66	22·92	52·97	18·04	14·21	0·789
—	5·09	1·83	1·33	1·49	0·720	0·518	—
—	0·150	0·06	0·06	0·03	0·04	0·04	—
1·000	38·88	32·14	24·08	53·33	18·13	14·30	0·791
—	6·01	1·75	1·52	1·38	0·623	0·569	—
—	0·155	0·05	0·06	0·03	0·03	0·04	—
1·002	44·82	33·66	25·22	53·75	18·25	14·27	0·783
—	7·46	1·77	1·70	1·30	0·578	0·522	—
—	0·166	0·05	0·07	0·02	0·03	0·04	—
1·007	48·06	34·27	25·97	54·16	18·30	14·49	0·793
—	8·42	1·82	1·71	1·62	0·662	0·516	—
—	0·175	0·05	0·07	0·03	0·04	0·04	—
1·007	52·93	35·16	26·98	54·51	18·53	14·56	0·786
—	7·79	1·73	1·30	1·39	0·676	0·50	—
—	0·147	0·05	0·05	0·03	0·04	0·03	—
1·010	54·60	35·71	27·22	54·85	18·71	14·66	0·784
—	6·60	1·61	1·08	1·42	0·597	0·496	—
—	0·121	0·05	0·04	0·03	0·03	0·03	—
1·001	56·97	35·79	28·03	54·85	18·72	14·93	0·797
—	8·20	1·99	1·82	1·36	0·687	0·677	—
—	0·144	0·06	0·06	0·02	0·04	0·05	—

C.V. = Coefficient of variation.

FIGS. 1 and 2.—Length, stem length and span compared in boys (Fig. 1) and girls (Fig. 2).

FIGS. 3 and 4.—Bi-acromial diameter and pelvic width compared in boys (Fig. 3) and girls (Fig. 4).

reduce or eliminate them. Thus, in Simmons' (1944) longitudinal study in which both erect height and recumbent length were measured on the same children, the recumbent length measurements are not consistently greater in boys than girls aged 5 to 9 years, although the measurements of erect height are greater for boys at each of these ages.

Comparison with Other Data. Stein (1953) found that in one working-class ward in Edinburgh in 1951/52 the means of height and weight of primary schoolchildren up to 12 years of age were lower than those found in London in 1949 (Daley, 1950). Using length adjusted for erect height, the present series confirms that samples of Edinburgh boys and girls are shorter than London schoolchildren up to the age of 12 years, but that from 12 to 15 years the heights of boys in both cities are closely similar, and that those of older Edinburgh girls approximate more nearly to the London figures. It should, however, be pointed out that the Edinburgh samples contain a slightly increased proportion of fee-paying pupils between 11 and 15 years. A comparison of weights at first suggests that the Edinburgh boys are on the average 1.15 kg. lighter and girls 1.39 kg. lighter than the London schoolchildren through the age-range 5 to 15 years, but an important discrepancy is introduced by the fact that the present series represents unclothed weights. Daley (1950) does not state whether the weights he quotes were unclothed weights, but as he compares these with the 1938 London figures and these are stated to be weights taken in indoor clothing without shoes (Menzies, 1940), it may be assumed that Daley's weights include clothing. A part (and possibly the major part) of the difference between the weights in the Edinburgh and London series is therefore attributable to clothing. This illustrates the necessity of recording techniques as well

as analyses of data when comparisons between different series of children's measurements are made, particularly when the observed differences are relatively small.

A more satisfactory comparison can be made with various American data in which unclothed weight is recorded, together with stem-length, shoulder-width, etc. For example, the figures given by Meredith and Meredith (1953) for Oregon children, more than 50% of whom were of British descent, do indicate significant differences from the Edinburgh children. Thus Oregon boys aged 10 years were more than 2.7 cm. taller and 2.6 kg. heavier than Edinburgh boys with a central age of 10.5 years. Oregon girls aged 11 years were more than 3 cm. taller and 3.7 kg. heavier than the Edinburgh girls with a central age of 11.5 years. The measurements of stem-length and shoulder-width also favoured the Oregon children, although the differences were relatively smaller.

Sexual Maturation. It has been repeatedly affirmed that the greater heights and weights of children of all ages which are commonly reported to-day compared, for instance, with those of similar groups 25 or more years ago, are at least partly due to earlier maturation. While radiological assessment of skeletal age (Todd, 1937) probably provides the most reliable index of maturation, such data are seldom available in earlier studies, and clinical assessment of age-onset of the various stages of sexual maturation (pubescence, menarche, etc.) still has considerable value.

From the figures given in Table 3, the median age of pubescence (i.e., the age at which 50% of the children were found to be non-pubescent and 50% pubescent or more mature) and the median age of 'adolescence' (i.e., advanced sexual maturity in boys and onset of menstruation in girls) was calculated for each sex to the first approximation of probit

TABLE 3
MATURITY GRADING
BOYS

Mean age (years)	5.51	6.50	7.59	8.46	9.51	10.51	11.60	12.57	13.47	14.54	15.40	16.57	17.47
Number	56	57	55	63	60	63	60	80	85	84	93	69	61
% Non-pubescent	100	100	100	100	100	100	95	77.5	47.1	21.4	6.5	1.4	0
% Pubescent	0	0	0	0	0	0	5	22.5	49.4	60.7	37.6	11.6	1.6
% Adolescent	0	0	0	0	0	0	0	0	3.5	17.9	55.9	87.0	98.4

GIRLS

Mean age (years)	5.60	6.54	7.49	8.49	9.51	10.48	11.52	12.54	13.49	14.51	15.40	16.48	17.46
Number	48	61	58	57	56	63	64	79	75	62	86	69	56
% Non-pubescent	100	100	100	100	94.6	79.4	46.9	11.4	1.4	0	0	0	0
% Pubescent	0	0	0	0	5.4	20.6	53.1	81.0	45.3	21.0	7.0	1.4	1.8
% Adolescent	0	0	0	0	0	0	0	7.6	53.3	79.0	93.0	98.6	98.2

analysis. Where comparisons are made with the data of Hogben, Waterhouse and Hogben (1948) the figures quoted are those obtained by probit analysis, although these authors expressed a preference for the logistic fit which gave somewhat lower values. Bryan and Greenberg (1952), however, who analysed their data on sexual maturation of girls by probits, logits and Karber's method, found that the three methods gave closely similar results, and considered that the first two held no advantage over Karber's method of calculating maturity points. The last method only was used by Bryan and Greenberg in determining the maturity of boys.

Boys. The median age of pubescence was found to be 13.45 years and that of adolescence 15.35 years. The first of these figures corresponds closely with that given by Ellis (1948) for boys in two residential schools in England, viz., 13.4 years where the same criteria were used and is comparable with the figure of 13.6 ± 1.05 years based on the presence or absence of pubic hair used by Hogben *et al.* (1948). Bryan and Greenberg (1952), who used Ellis's criteria in grading boys, gave 13.1 years as the 50% immaturity point in their American study. The duration of pubescence at median age would thus be 1.9 years in the present series compared with approximately 1.2 years in the first English series. Ellis's figures suggested that the duration of pubescence was longer in the case of boys reaching pubescence early or late. Graphic representation of the present figures for boys non-pubescent and non-adolescent gives some support to this view as far as the boys reaching pubescence early are concerned, viz., 2.2 years when pubescence is reached at 11.5 years and 2.1 years when reached at 12.5 years, but for those reaching pubescence at 14.5 years the duration is approximately 1.7 years, i.e., less than at the median age. Since the curves in the present series are considerably more symmetrical than the English series (where the upper age groups were supplemented by boys in employment from a different sample) it appears probable that a longer duration of pubescence in boys who mature late is not a consistent finding. As was pointed out, however, duration of pubescence in early and late maturing boys can only be accurately assessed by longitudinal studies.

GIRLS. The median age of reaching pubescence, as indicated by evidence of breast development, was 11.30 years and of adolescence (menarche) 13.35 years. The first figure corresponds fairly closely with that given by Hogben *et al.* (1948) for English schoolgirls, viz., 11.5 ± 0.83 years, but is significantly later than the age given by Bryan and Greenberg

(1952) for American schoolgirls, viz., 10.6 ± 0.24 years. Considerably more comparative data exist for both the mean and median age of menarche, and since there is evidence that the distribution of age of menarche is approximately symmetrical (Ellis, 1947; Wilson and Sutherland, 1950), it is possible to compare the median age in the present series with either the mean or median of other British series, e.g., median 13.49 ± 1.19 years in 2,590 day-school pupils (Wilson and Sutherland, 1950). Again it will be seen that there is reasonably close correspondence between the Edinburgh figures and recent data collected in England. The calculated duration of pubescence at median age in the Edinburgh series is 2.05 years, which may be compared with the figure of 2.5 years given by Hogben *et al.* (1948) as the time interval between the appearance of breast development and the onset of menstruation.

Sex Differences in Maturation. These figures give clear confirmation to the observations of previous authors (e.g., Cawley, Waterhouse and Hogben, 1949) that boys begin to show evidence of sexual maturation on the average two years (here 2.1 years) later than girls. Furthermore, the clinical assessment of the later stage of maturity described as 'adolescence', which is admittedly somewhat arbitrary and subjective in the case of boys, defines a median value which in this series falls exactly two years later than the median age of the menarche in girls. The maintenance of this two-year sex difference suggests that the criteria adopted for defining 'adolescence' in boys (Ellis, 1946) do have

FIG. 5.—Percentage of boys non-pubescent, pubescent and adolescent in each year of age.

FIG. 6.—Percentage of girls non-pubescent, pubescent and adolescent in each year of age.

a practical value in assessing a stage of male maturity corresponding approximately to the menarche in girls. Figs. 5 and 6 show the results graphically, from which it will be seen that whilst the general pattern of maturation is similar in the two sexes, the corresponding stages of development are reached on the average two years later in boys than in girls.

Secular Changes in Maturation. In 1933, Kennedy published data on the mean age of the menarche of women resident in Edinburgh or its environs, based on an analysis of 10,219 hospital records. Although hospital patients cannot be accepted as a normal population, and the data would cover a considerable period before the date of publication, since most of the women were middle-aged at the time of the enquiry, the fact that the mean age of the menarche was found to be 15.037 years with a standard deviation of 1.707 years strongly indicates that sexual maturation in Edinburgh schoolgirls is now occurring significantly earlier than at the beginning of the century. There are no reliable data for this period relating to Edinburgh boys, but it has been observed since the days of the Talmud that boys mature later than girls, and many early writers have estimated the sex difference as 18 months to two years. Since the same sex-difference appears in the 1951/53 figures, it may reasonably be assumed that boys are also maturing earlier.

This earlier maturation, and the associated increase in mean heights and weights of school-

children, are presumably due largely to improvement in nutrition and socio-economic conditions in the intervening years. It should be borne in mind, however, that attainment of maturity, at whatever age it occurs, is followed by rapid deceleration and cessation of growth, and that terminal or adult stature will be reached sooner in children who mature early. It would seem that although both speed of maturation and terminal height are genetically controlled, environment can influence the former to a relatively greater extent than it can adult stature.

Summary and Conclusions

Anthropometric data on 1,730 Edinburgh schoolchildren are presented. Nine body measurements were made on each child. Ratios are given for stem-length/crown-heel length, span/crown-heel length and cephalic index.

The methods of sampling, measurement, analysis and grading maturity are described.

The measurement of recumbent crown-heel length is discussed and compared with that of erect height.

The results of maturity grading are compared with those of other recent British studies, and contrasted with earlier Edinburgh data on the age of the menarche.

The present study supports the view that schoolchildren are maturing earlier now than at the beginning of the century.

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