AN ANTHROPOMETRIC STUDY OF PREMATURELY BORN CHILDREN AT THE AGE OF 5 YEARS

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A considerable number of growth studies on prematurely born children have been carried out since 1919 when Ylppö (1920) published the first major report on this subject (Capper, 1928; Hess, Mohr and Bartelme, 1934; von Sydow, 1936; Illingworth, 1939; Brander, 1941; Levine and Gordon, 1942; Asher, 1946; Drillien, 1948; Alm, 1953; Douglas and Mogford, 1953). The earlier results are unreliable and contradictory, but later workers agree in general that premature infants remain a little below average in height and weight. With a steady increase in survival rate the characteristics of this group of children are likely to alter. In addition, racial, economic and other factors have an important bearing on growth pattern. Therefore as there are no detailed anthropometric data on Scottish children born prematurely the present investigation was undertaken.

Material

This paper presents the results of an anthropometric study of children born prematurely (birth weight 2·5 kg. or less) in Glasgow Royal Maternity and Women's Hospital in 1949. Children with a birth weight over 2·5 kg. born in the same hospital in the same year were used as controls. The period during which measurements were made extended from September, 1954, until May, 1955.

Of the infants delivered prematurely in 1949, 316 left hospital. Details of their subsequent history are as follows:

Died after discharge	19
Emigrated	9
Removed from Glasgow (traced) ..	33
Removed from Glasgow (not traced) ..	32
Adopted	4
Visited but uncooperative	2
Attended for measurement	217
Total	316

Thus, 217 or 68·7% of the original sample of premature infants were measured. This figure compares favourably with that of other studies and

seems as high as it is possible to reach without a large team of workers. Although those who were measured cannot be regarded as entirely representative, there is no evidence that the sample measured would differ significantly from the whole group.

To obtain a control group an attempt was made to trace each fifth mature child dismissed from hospital at the same period. As in the premature group a proportion could not be traced so the next fifth child on the list was chosen and so on until an equal number was obtained. A few from 1950 were taken towards the end of the survey to reach the required total. The number, birth weight and sex of the children in each group is shown in Table 1.

TABLE 1
BIRTH WEIGHT AND SEX DISTRIBUTION OF CHILDREN

Premature			Mature		
Birth Weight	M	F	Birth Weight	M	F
2 lb. -2 lb. 8 oz. (0·91-1·13 kg.)	1	—	5 lb. 9 oz.-6 lb. (2·52-2·72 kg.)	11	11
2 lb. 9 oz.-3 lb. (1·16-1·36 kg.)	2	1	6 lb. 1 oz.-6 lb. 8 oz. (2·75-2·95 kg.)	12	17
3 lb. 1 oz.-3 lb. 8 oz. (1·39-1·59 kg.)	5	5	6 lb. 9 oz.-7 lb. (2·98-3·17 kg.)	18	21
3 lb. 9 oz.-4 lb. (1·62-1·81 kg.)	8	6	7 lb. 1 oz.-7 lb. 8 oz. (3·2-3·41 kg.)	17	21
4 lb. 1 oz.-4 lb. 8 oz. (1·84-2·04 kg.)	25	22	7 lb. 9 oz.-8 lb. (3·43-3·63 kg.)	19	16
4 lb. 9 oz.-5 lb. (2·07-2·27 kg.)	27	32	8 lb. 1 oz.-8 lb. 8 oz. (3·66-3·86 kg.)	18	10
5 lb. 1 oz.-5 lb. 8 oz. (2·30-2·50 kg.)	37	46	8 lb. 9 oz.-9 lb. (3·88-4·08 kg.)	11	3
			9 lb. 1 oz.-9 lb. 8 oz. (4·11-4·31 kg.)	4	6
			9 lb. 9 oz.-10 lb. (4·34-4·54 kg.)	4	2
			Over 10 lb. (>4·54 kg.)	—	1
Totals	105	112		114	108

Methods

The survey was undertaken with the help of a health visitor seconded from Glasgow Corporation Public Health Department. The procedure was essentially the same in both groups of children. The health visitor tried to trace each infant and visit the home. She then invited the mother to attend

the Royal Hospital for Sick Children with her child for measurement. At the same time information was obtained of the child's past history, of the socio-economic conditions and other details of the home situation. It is of interest that only 24% of the mothers of prematures gave the correct birth weight as compared with 37% of the mothers of the mature infants.

The tracing of these children was rendered extraordinarily difficult by the remarkable shift of population to new housing estates which occurred in Glasgow in this post-war period. Approximately one-third of the children were not traceable at the 1949 address. The frequency with which they moved house was also extraordinary, five removals within five years being not infrequent. The assistance of the Public Health Department, Local Executive Council, school attendance officers and many others was invoked and proved very useful. We would thank them for their services.

It became apparent early in the investigation that it was going to be impossible to have each child attend hospital on or near the fifth birthday. As we were anxious to obtain measurements of as many of the original prematures as possible we had therefore to forego this.

In 40 cases the parents, though agreeable to having their children measured, could not or would not bring them to hospital. This was overcome by visiting them at school and measuring them there.

Comparability of the Premature and Mature Groups

Without resorting to pairing it was felt that both groups should be comparable as far as socio-economic factors are concerned as the patients delivered in Glasgow Maternity Hospital tend to be of a rather homogeneous and poor socio-economic group. The two groups were subsequently studied with regard to housing, social class, maternal age and birth order, factors which have a bearing on birth weight and subsequent growth. Details are presented in Tables 2, 3, 4 and 5. These show that

TABLE 2
BIRTH ORDER OF CHILDREN MEASURED

Birth Order	Premature	Mature
1st	84	84
2nd	56	62
3rd	18	24
4th	23	22
5th	16	13
6th	4	3
7th	2	4
8th	4	4
9th —	9	6
Unknown	1	—
Total	217	222

TABLE 3
AGE OF MOTHER AT BIRTH

	Premature	Mature
20 years and under	12	15
21-25 years	54	52
26-30 years	52	64
31-35 years	50	37
36-40 years	34	42
41 years and over	14	12
Unknown	1	—
Total	217	222

TABLE 4
SOCIAL CLASS

Social Class	Premature	Mature
I	1	—
II	28	25
III	84	112
IV	26	19
V	73	63
Unclassified	5	3
Total	217	222

TABLE 5
HOUSING

Inmates per Room	Premature	Mature
0.4	1	—
0.5	1	3
0.75	6	—
0.8	1	23
1.0	18	—
1.14	1	7
1.25	14	—
1.33	15	21
1.4	1	—
1.5	35	55
1.6	1	8
1.67	14	—
1.75	6	—
2	26	21
2.25	2	3
2.33	3	4
2.5	3	13
2.67	2	1
Over-crowded	37	43
3.5	—	4
4	18	12
4.5	1	2
5	4	1
5.5	2	1
6	1	—
7	3	—

with regard to birth order there is no difference between the two groups. Forty-seven per cent. of the prematures and 47.3% of the controls came from overcrowded houses (two or more inmates per room), though more prematures came from very bad or very good homes. Slightly more prematures came from social classes IV and V, whereas approximately half the matures came from social class III. This difference is just significant. The illegitimacy rate was 5.0% in the premature group and 2.2% in

the control, such a low rate as not to affect the comparability of the groups. It is clear therefore that apart from a slight difference in social class the two groups are comparable.

Measurements Undertaken

Six body measurements were selected from those used in the Harpenden Growth Survey (Tanner, 1955), namely height, weight, sitting height, bi-acromial diameter, bi-iliac diameter and subcutaneous fold thickness. One operator (H.V.) undertook all the height and weight measurements, while the other (A.L.S.) undertook the rest, an arrangement which was maintained throughout the survey.

The same instruments were used throughout, except in the case of 40 children in the premature group who had to be visited in school in order to obtain their measurements. In this instance the heights and weights were recorded from the local authority school instruments. The weighing machines were of standard lever type.

Height, Weight and Sitting Height. These were all measured according to the method described in a standard textbook (Nelson, 1954). All children were weighed naked. Height and sitting height were measured to within 0.25 cm. and weight to within 50 g.

Subcutaneous Fold Thickness. As changes in fold thickness at one site are representative of changes over the rest of the body (Edwards, 1950; Hammond, 1955a) only one site was studied. Of the areas recommended by Tanner (1955) that just below the angle of the left scapula was selected. The Harpenden Growth Study (or M.R.C.) calipers, with plate sizes 6×15 mm. and pressure 10 g./mm.², were used. A certain amount of 'drift' occurred if pressure was maintained, due to squeezing of the tissue. After some experience a relatively standard period of pressure (which avoided much squeezing) was used throughout. The reading on the dial gauge was taken to 0.1 mm.

Bi-acromial and Bi-iliac Diameters. These were taken with sliding calipers which were guided into the correct position by extending the fingers along the arms of the calipers and feeling for the bony prominences which, in this instance, were the most lateral points of the acromion processes and the most lateral points of the iliac crests. These were taken with the child standing erect with arms to the sides and were recorded to the nearest 0.1 cm.

Duplicate and sometimes triplicate measurements were taken in a proportion of cases to see how far the figures obtained were repeatable. For inclusion in the final figures a mean of the readings was used.

Accuracy of Certain Measurements

Height and weight can be measured with a fair degree of accuracy, but this is not likely to be so in the case of certain of the other measurements undertaken. Bi-acromial diameter is very easily varied by a child's tendency to shrug his shoulders or shrink when calipers are placed across them, a tendency which is difficult to overcome completely in many children. It is also difficult to standardize the period for which the skin-fold calipers are applied; maintenance of pressure results in erroneously low readings. In addition, slight variations in the site of application below the angle of the scapula can produce surprising variation in the figures obtained.

The best measure of reliability is given by the coefficients of variation from repeated measurements taken during one examination. The results in the 180 cases in which this was done are as follows:

	Subcutaneous Fold Thickness	Bi-acromial Diameter	Bi-iliac Diameter
Coefficient of variation	3.6%	0.92%	0.65%

A coefficient of variation of 1% is very satisfactory. It roughly means that the true value corresponding to an observed value will lie within $\pm 2\%$ of the observed value. The coefficient of variation of 3.6% associated with fold thickness is rather too high, though is still satisfactory.

Results

The ages of the premature children ranged from 4 years 9 months to 6 years 2 months and of the mature children from 4 years 3 months to 6 years. Before the differences in weight, etc., could be examined it was necessary to adjust the measures to a standard age. The male premature children had a mean age of 5 years 6.1 months and the male mature a mean age of 5 years 3.2 months. To reduce the errors of estimate the measures of weight, etc., were adjusted to the age of 5 years 4.6 months, which is the mean age of all male (premature and mature) children. Similarly, the measures of the female children were adjusted to the age of 5 years 4.4 months. To make these adjustments the average rate of increase (or decrease) was determined for all males and females separately by the use of linear regression equations for each of the

variables (weight, height, etc.) and multiplied by the difference in age between the actual and the standard ages; this product was then subtracted from the actual weight or height, etc., of the child. In practice the adjustment was made only to the mean values. Thus, for example, the linear regression of weight on age for male children gave an average growth of 0.904 kg. per year and the adjusted mean weight for premature males

$$= \text{actual mean weight} - 0.904 (5.506 - 5.383) \\ = 17.666 - 0.904 (-0.123) \\ = 17.555 \text{ kg.} = 17.56 \text{ kg.}$$

where the mean age of all premature males is 5.506 years, and the mean age of all (mature and premature) males is 5.383 years.

The results of this statistical analysis are presented in Table 6.

TABLE 6
MEAN VALUES OF MEASUREMENTS IN
PREMATURE AND MATURE GROUPS

	Mean Values			
	Males Adjusted to Age 5 yr. 4-6 mth.		Females Adjusted to Age 5 yr. 4-4 mth.	
	Premature	Mature	Premature	Mature
Weight (kg.)	17.56*	18.73	16.74*	18.19
Height (cm.)	106.22*	108.00	104.69*	107.32
Sitting height (cm.)	61.07	61.58	59.96*	60.99
Subcutaneous fold thickness (mm.)	5.52	4.96	5.55	5.67
Bi-iliac diameter (cm.)	17.74*	18.10	17.39*	17.77
Biacromial diameter (cm.)	23.57*	24.04	23.00*	23.69

* Denotes significant differences between premature and mature children.

Discussion

The results indicate that the height, weight and breadth of children born prematurely in Glasgow in 1949 were less than in a comparable group of full-term children aged 5 years. The differences are statistically significant in both sexes and for each measurement except for sitting height in males. With respect to height and weight these results are in agreement with recent work. The findings for sitting height and bi-iliac (intercrystal) diameter are in agreement with those of Hess *et al.* (1934) in the United States.

The subcutaneous fold thickness is unique in that

there is no significant difference between the mature and premature groups. This is not surprising as subcutaneous fat normally decreases in thickness until the ages of 5 or 6 years, whereas other measurements increase with age (Stuart and Sobel, 1946; Hammond, 1955b). The figures found by Hammond for a group of 5-year-old children are similar to those found in the mature children in this series:

	Subcutaneous Fold Thickness at Subscapular Site (mm.)	
	Males	Females
Glasgow mature group	4.96	5.67
Hammond (1955b)	4.97	5.18

It is apparent that girls are fatter than boys, though this difference is negligible in the premature children.

A comparison of the figures for the mature group with those from other centres is also of interest. The weight and biacromial diameters of a representative sample of Edinburgh schoolchildren aged 5 years as reported by Provis and Ellis (1955) are in each instance very similar but slightly greater than those for the mature Glasgow children aged 5 years 4 months.

	Glasgow		Edinburgh	
	Male	Female	Male	Female
Weight (kg.)	18.73	18.19	19.01	18.9
Biacromial diameter (cm.)	24.04	23.69	24.47	24.72

The difference is probably mainly due to the fact that the Glasgow children come from a poorer socio-economic group. This is confirmed by a further comparison with Hammond's (1953) figures for schoolchildren in the north of England which show that height, weight, sitting height and biacromial diameter in the mature Glasgow group are all very much more closely related to those measurements in children from council schools (poor districts) as opposed to independent schools. Hammond's (1955a) latest figures for an average sample of Leeds' children are mid-way between (Table 7).

TABLE 7
COMPARISON BETWEEN MATURE CHILDREN AND OTHER GROUPS OF 5 YEARS OLD
REPORTED BY HAMMOND (1953 AND 1955a)

	Weight (kg.)		Height (in.)		Sitting Height (in.)		Biacromial Diameter (in.)	
	M	F	M	F	M	F	M	F
Glasgow—mature group	18.73	18.19	108.0	107.32	61.58	60.99	24.04	23.69
Average Leeds children	18.69	19.02	110.0	110.3	62.3	62.1	24.3	24.2
Independent schoolchildren	20.9	19.4	115.2	113.7	65.6	63.8	24.7	24.3
Council schoolchildren	18.45	18.41	108.0	107.8	61.4	60.5	23.3	23.2

There seems to be disagreement between various reports as to whether boys at this age have broader shoulders than girls. Thus Provis and Ellis (1955) and Hogben, Waterhouse and Hogben (1948) found the mean shoulder width of the girls to be greater than the boys', whereas the reverse was found by Hammond (1953) and in this series. The differences are, however, slight and could result from the less satisfactory nature of this measurement already mentioned.

Because of the age range of the children under survey it was possible to calculate apparent rates of growth for each of the four main groups of children. These showed no significant difference between the mature males, the premature males and the premature females. For some reason which is not clear the mature females had an apparently greater growth rate in most of the features studied throughout the age range. These figures have, however, not been published as they were derived from a cross-sectional and not a longitudinal study.

Summary

The present paper reports the results of a cross-sectional anthropometric study on 217 prematurely born and 222 full-term Glasgow children aged 5 years.

The two groups were analysed with regard to factors which have a bearing on subsequent growth and were found to be similar except for a slight bias towards poorer social class in the premature group.

Six measurements were recorded, namely, height, weight, sitting height, subcutaneous fold thickness, biacromial diameter and bi-iliac diameter.

With the exception of subcutaneous fold thickness in boys and girls and sitting height in boys the measurements for the mature children were significantly greater than those for the premature when the series are compared separately.

Certain measurements were compared with those in other series and in general the results found to be similar.

I wish to record my sincere thanks to Professor Stanley Graham for his guidance and help, to Dr. R. A. Robb of the Department of Statistics, Glasgow University, for his extensive statistical analysis, and to Miss Marshall, lately health visitor with Glasgow Corporation, for her tireless efforts in tracing these children and helping with the survey.

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