A LONGITUDINAL STUDY OF THE GROWTH AND DEVELOPMENT OF PREMATURELY AND MATURELY BORN CHILDREN

PART VI: PHYSICAL DEVELOPMENT IN AGE PERIOD 2 TO 4 YEARS

BY

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In previous papers in this series (Drillien, 1958a, b; 1959a, b, c) an account has been given of growth and development during the first two years of life of nearly 600 children of different birth weight. These children were born in two Edinburgh maternity hospitals, in the years 1953 to 1955. Approximately one-third of the group were $4\frac{1}{2}$ lb. or less at birth, one-third between $4\frac{1}{2}$ and $5\frac{1}{2}$ lb., and one-third mature controls. The sample includes over 100 pairs of twins. Details of selection and procedure are given elsewhere (Drillien, 1958a). All children in the survey have now reached the age of 4 years, and results are presented here of the analyses of weight and height measurements, in relation to birth weight, sex, whether single or multiple birth, and certain environmental and genetic factors.

Five hundred and ninety-five children were originally selected for study. Of these, 58 (10 of whom died) were lost at or before 2 years. Between 2 and 4 years a further nine children have been lost. Most of the losses have been due to removal from Edinburgh or south Scotland. Only seven children have been lost through refusal of the parents to co-operate, all these before the age of 2 years. At 3 years 92% of surviving children remained in the survey, and at 4 years 90% remained. This wastage rate compares favourably with other longitudinal surveys of this kind. In the Newcastle study (Miller, Court, Walton and Knox, 1960) 78.5% remained at 5 years. Here the major cause of loss was removal from the city, with an excess in families from the two highest social classes. In the Edinburgh survey, children are retained in the sample if they remove to within a radius of about 60 miles, and others have been seen on return to Scotland for holidays. The majority of those lost by removal have emigrated. The social class distribution of those remaining at 4 years does not differ appreci-

ably from that of the original sample. In the national survey of premature and maturely born children (Douglas and Blomfield, 1958) 31% had been lost by $4\frac{1}{2}$ years, most of these due to death; after the exclusion of deaths 94% remained. In the national survey each premature was matched with a maturely born control child, and when either was lost the paired child was also excluded. This is likely to introduce bias if death rates differ in the experimental and control groups, as is the case here. Yearly death rates per 1,000 survivors, between the ages of 1 month and $4\frac{1}{2}$ years, were 14.1% for prematures and 4.4% for controls. Excluding the paired controls has the effect of artificially eliminating these children.

Procedure

Nearly all the children were examined within two weeks of their 3rd and 4th birthdays. Any who were seen later than four weeks after their birthdays have not been included in the subsequent analysis. At 3 years 14 cases were excluded for this reason, and 16 cases at 4 years.

The children have been examined in their own homes. They were weighed in light indoor clothes, without shoes, an appropriate deduction being made for clothes still worn, and measured recumbent, without shoes, on a portable measuring board.

Mean Measurements of Weight and Height

Tables 1-4 give mean weights and heights, mean weight and height increments, and the standard deviations of these means for male and female singletons and twins in four birth weight groups, at ages 1, 2, 3 and 4 years. The means are recorded in British units and their metric equivalents. At

TABLE 1: MEAN WEIGHTS AND HEIGHTS OF MALE SINGLETONS AND TWINS AT AGES 1-4 YEARS

Age (yrs)	Birth Weight*	Weight (lb.)	S.D. (oz.)	Weight (kg.)	S.D. (g.)	No. of Cases	Height (in.)	S.D. (in.)	Height (cm.)	S.D. (cm.)	No. of Cases
Male Singletons											
1	1	19.3	6	8.750	182	53					
	2	21.0	5	9.545	127	62					
	3	22.9	8	10.398	236	26					
	4	23.9	7	10.881	191	30					
2	1	24.6	7	11.193	186	52	31.9	0.67	81.1	1.70	52
	2	25.5	5	11.591	136	63	33.1	0.15	84.0	0.37	63
	3	27.4	9	12.472	240	26	34.2	0.58	86.8	1.47	26
	4	28.6	9	12.983	254	30	34.2	0.23	87.4	0.58	27
3	1	28.9	7	13.153	209	49	35.8	0.54	91.0	1.38	49
	2	29.8	6	13.551	159	63	36.5	0.52	92.6	1.31	63
	3	32.1	10	14.602	277	26	37.4	0.84	95.1	2.13	25
	4	33.1	11	15.028	308	28	37.6	0.82	95.5	2.09	27
4	1	33.1	9	15.028	249	45	38.7	1.1	98.4	2.75	45
	2	33.8	7	15.369	195	60	39.3	0.61	99.9	1.55	60
	3	36.6	12	16.619	336	24	40.6	0.96	103.0	2.44	24
	4	37.4	14	17.017	404	29	40.5	0.80	102.8	2.02	29
Male Twins											
1	1	18.5	7	8.409	204	25					
	2	20.4	9	9.290	254	28					
	3	22.6	6	10.284	163	39					
	4	22.8	9	10.369	254	6					
2	1	23.5	8	10.682	240	27	32.4	0.33	82.3	0.85	24
	2	25.6	7	11.648	200	28	33.0	0.24	83.8	0.61	28
	3	27.6	7	12.557	209	39	34.0	0.21	86.3	0.53	38
	4	28.1	18	12.784	500	5	33.4	0.31	84.8	0.80	5
3	1	28.3	11	12.869	304	25	35.8	1.35	91.0	3.44	25
	2	29.7	9	13.466	263	28	36.4	0.84	92.5	2.14	28
	3	32.0	9	14.545	259	36	37.2	0.76	94.6	1.93	36
	4	34.6	11	15.710	308	3	37.3	3.20	94.8	8.18	3
4	1	32.1	12	14.574	349	25	38.5	1.49	97.8	3.78	25
	2	33.3	9	15.114	263	27	39.1	1.01	99.4	2.57	27
	3	35.9	11	16.335	313	36	40.0	0.84	101.6	2.13	36
	4	36.6	4	16.619	953	4	39.7	1.20	100.8	6.24	4

TABLE 2: MEAN WEIGHTS AND HEIGHTS OF FEMALE SINGLETONS AND TWINS AT AGES 1-4 YEARS

Age (yrs)	Birth Weight*	Weight (lb.)	S.D. (oz.)	Weight (kg.)	S.D. (g.)	No. of Cases	Height (in.)	S.D. (in.)	Height (cm.)	S.D. (cm.)	No. of Cases
Female Singletons											
1	1	19.2	7	8.693	191	47					
	2	20.0	7	9.091	186	75					
	3	21.2	7	9.631	186	40					
	4	22.9	10	10.426	281	20					
2	1	24.4	7	11.080	195	42	32.6	0.26	82.7	0.65	42
	2	24.7	6	11.222	168	75	32.8	0.17	83.2	0.43	74
	3	25.9	6	11.761	154	38	33.5	0.21	85.2	0.53	37
	4	27.5	10	12.500	295	19	34.0	0.27	86.4	0.68	19
3	1	28.8	9	13.096	254	44	36.0	0.90	91.5	2.28	44
	2	28.9	7	13.125	186	73	35.9	0.47	91.2	1.20	73
	3	30.5	8	13.864	236	38	36.7	0.72	93.1	1.82	38
	4	32.5	13	14.773	376	19	37.5	1.28	95.2	3.24	19
4	1	32.7	11	14.886	304	44	38.9	1.03	98.7	2.62	42
	2	32.5	8	14.773	218	71	38.7	0.61	98.2	1.56	71
	3	34.4	11	15.623	313	35	39.6	0.89	100.5	2.27	35
	4	37.3	18	16.960	499	19	40.3	1.52	102.4	3.86	19
Female Twins											
1	1	18.1	8	8.239	213	30					
	2	20.0	13	9.091	367	32					
	3	21.4	6	9.716	181	36					
	4	23.7	11	10.767	318	5					
2	1	23.3	8	10.597	227	30	31.8	0.26	80.7	0.65	28
	2	24.4	10	11.080	286	28	32.4	0.28	82.3	0.71	28
	3	25.9	6	11.790	168	33	33.2	0.25	84.4	0.63	32
	4	29.1	7	13.239	191	5	34.4	1.50	87.5	3.70	5
3	1	27.8	11	12.614	313	28	35.3	1.02	89.6	2.58	28
	2	28.1	11	12.756	299	27	35.4	0.92	90.0	2.34	27
	3	30.2	8	13.722	222	33	36.5	0.86	92.8	2.19	33
	4	35.0	25	15.909	699	5	37.8	1.20	95.9	3.10	5
4	1	31.4	13	14.290	358	28	37.8	1.09	96.0	2.77	28
	2	32.1	12	14.602	340	27	38.5	0.89	97.7	2.27	27
	3	34.8	10	15.795	290	33	39.5	0.91	100.5	2.30	33
	4	39.4	36	17.899	1,016	5	41.0	1.36	104.1	3.46	5

* Birth weight, lb. oz. (g.): 1 = 4.8 and under (2,045 g. and under) 3 = 5.9-7.8 (2,501-3,409 g.)
2 = 4.9-5.8 (2,046-2,500 g.) 4 = 7.9 and over (3,410 g. and over)

TABLE 3: MEAN WEIGHT AND HEIGHT INCREMENTS OF MALE SINGLETONS AND TWINS AT AGES 1-4 YEARS

Age (yrs)	Birth Weight	Weight Increment					Height Increment				
		(lb.)	S.D. (oz.)	(kg.)	S.D. (g.)	No. of Cases	(in.)	S.D. (in.)	(cm.)	S.D. (cm.)	No. of Cases
Male Singletons											
1	1	15.7	6	7.121	172	53					
	2	15.9	4	7.212	127	62					
	3	15.9	9	7.212	245	26					
	4	15.4	7	6.985	186	30					
2	1	20.9	7	9.480	186	52	15.3	0.35	38.9	0.90	52
	2	20.4	5	9.253	145	63	14.9	0.19	37.9	0.47	63
	3	20.5	8	9.299	236	26	14.4	0.36	36.5	0.91	26
	4	20.1	9	9.117	245	30	13.9	0.25	35.4	0.63	27
3	1	25.3	7	11.476	200	49	18.9	0.62	48.0	1.58	49
	2	24.7	6	11.204	159	63	18.3	0.57	46.4	1.44	63
	3	25.2	10	11.431	277	26	17.5	1.00	44.8	2.53	25
	4	24.5	10	11.113	281	28	17.1	0.85	43.4	2.16	27
4	1	29.3	9	13.290	259	45	21.7	0.88	55.0	2.23	45
	2	28.6	7	12.973	204	60	21.1	0.63	53.7	1.59	60
	3	29.6	12	13.426	331	24	20.8	1.10	52.7	2.79	24
	4	28.9	13	13.109	367	29	19.8	0.82	50.4	2.09	29
Male Twins											
1	1	14.7	8	6.600	222	25					
	2	15.5	10	7.031	272	28					
	3	16.1	6	7.303	163	39					
	4	15.0	9	6.804	268	6					
2	1	19.5	8	8.845	240	27	15.2	0.28	38.6	0.71	24
	2	20.4	7	9.253	204	28	14.6	0.30	37.0	0.77	28
	3	21.4	8	9.707	222	39	14.5	0.25	36.9	0.63	38
	4	20.3	19	9.208	535	5	13.1	0.42	33.4	1.07	5
3	1	24.3	11	11.022	304	25	18.7	1.57	47.5	3.99	25
	2	24.5	9	11.113	268	28	18.0	0.97	45.7	2.46	28
	3	25.7	9	11.657	254	36	17.8	0.85	45.2	2.16	36
	4	26.9	10	12.202	295	3	17.2	2.79	43.7	7.09	3
4	1	28.0	11	12.701	304	25	21.4	1.60	54.5	4.07	25
	2	28.0	9	12.701	268	27	20.8	1.02	52.7	2.74	27
	3	29.6	10	13.426	295	36	20.4	0.89	51.9	2.27	36
	4	28.7	35	13.018	993	4	19.3	2.50	49.0	6.36	4

TABLE 4: MEAN WEIGHT AND HEIGHT INCREMENTS OF FEMALE SINGLETONS AND TWINS AT AGES 1-4 YEARS

Age (yrs)	Birth Weight	Weight Increment					Height Increment				
		(lb.)	S.D. (oz.)	(kg.)	S.D. (g.)	No. of Cases	(in.)	S.D. (in.)	(cm.)	S.D. (cm.)	No. of Cases
Female Singletons											
1	1	15.5	4	7.031	104	47					
	2	15.2	5	6.895	136	75					
	3	14.4	6	6.532	172	40					
	4	14.9	12	6.759	327	20					
2	1	20.3	11	9.185	308	42	15.6	0.25	39.5	0.64	42
	2	19.6	5	8.890	154	75	14.5	0.18	36.8	0.45	74
	3	19.1	6	8.664	181	38	15.0	0.28	38.0	0.72	37
	4	19.3	10	8.754	281	19	13.7	0.26	34.9	0.66	19
3	1	25.1	9	11.385	245	44	18.9	0.90	48.0	2.28	44
	2	23.8	6	10.795	172	73	17.9	0.61	45.4	1.56	73
	3	24.1	9	10.932	263	38	17.2	0.79	43.7	2.00	38
	4	24.3	13	11.022	367	19	17.1	1.27	43.5	3.22	19
4	1	29.1	10	13.200	295	44	21.8	1.00	55.3	2.55	42
	2	27.4	7	12.428	204	71	20.5	0.62	52.0	1.58	71
	3	27.6	11	12.519	299	35	20.0	0.99	50.9	2.52	35
	4	29.1	17	13.200	481	19	19.9	1.52	50.6	3.87	19
Female Twins											
1	1	14.4	7	6.532	209	30					
	2	15.1	8	6.849	218	32					
	3	15.1	7	6.849	186	36					
	4	15.6	9	7.076	263	5					
2	1	19.4	8	8.800	218	30	15.0	0.26	38.1	0.67	28
	2	19.4	10	8.800	286	28	14.3	0.31	36.3	0.79	28
	3	19.6	6	8.890	163	33	13.7	0.30	34.9	0.77	32
	4	21.3	6	9.662	163	5	14.5	0.37	36.9	0.94	5
3	1	23.9	11	10.841	299	28	18.1	1.19	46.1	3.02	28
	2	23.0	11	10.433	299	27	17.3	1.12	43.9	2.84	27
	3	23.8	7	10.795	209	33	17.0	1.07	43.2	2.72	33
	4	26.9	23	12.202	653	5	17.2	1.12	43.8	2.85	5
4	1	27.6	11	12.519	299	28	21.0	1.20	53.2	3.16	28
	2	27.1	12	12.292	336	27	20.5	1.44	52.0	3.65	27
	3	28.4	10	12.882	272	33	20.1	1.07	50.9	2.73	33
	4	31.3	34	14.175	966	5	20.5	1.13	52.0	2.87	5

each age mean weight is related to birth weight, and the prematurely born show little tendency to overcome their initial weight handicap. In general, the highest weight increments for singletons are recorded for those who were $4\frac{1}{2}$ lb. or less at birth. At ages 3 and 4 the lowest increments are those in the $4\frac{1}{2}$ to $5\frac{1}{2}$ lb. group. This group includes a preponderance of small full-term children, and the significance of this is discussed in a later section. At 4 years there is an excess in mean weight increment for those over $5\frac{1}{2}$ lb. at birth, as compared with those who were $5\frac{1}{2}$ lb. or less, amounting to 5 oz. for boys and 1 oz. for girls. This small difference has no practical or statistical significance. One may say that for the total premature group the singleton is as far behind in actual weight at 4 years as he was at birth.

Amongst twin births there is quite a marked difference in four-year weight increment by birth weight, increment being greater for those over $5\frac{1}{2}$ lb. by 1.5 lb. for boys and 1.4 lb. for girls. This difference is statistically significant ($p < 0.02$). For all birth weight groups twins are lighter at 4 years, as compared with singletons, the difference being most marked in those who were $4\frac{1}{2}$ lb. or less at birth. In this group twin boys are 1 lb. lighter than singletons, and twin girls 1.3 lb. lighter.

At 4 years larger weight increments are recorded for boys than girls, amounting to 0.75 lb. for premature and just over 1 lb. for maturely born singletons, and 0.75 lb. for twins of all birth weights. At 6 months the excess male weight increment for singletons was 11 oz. for premature and 18 oz. for maturely born male singletons, and 7 oz. and 14 oz. for premature and maturely born male twins. The difference in weight gain between the sexes at 4 years is almost identical. Falkner (1958) noted that rate of growth was very similar for singleton boys and girls up to the age of 3 years, except for an excess male weight gain in the first three months.

Mean measurements of height show that at 4 years of age the prematurely born are still shorter than the mature controls by between 1 and $1\frac{1}{2}$ inches. However, in all groups of male and female singletons and twins, height increments are related inversely to size at birth. There appears to be a definite tendency for those smallest at birth to reduce their initial height handicap more quickly than their weight handicap, and at 4 years they tend to be underweight, as compared with mature controls of like height.

Height increments are approximately equal for boys and girls, being 21.4 and 21.0 in. for male and female premature singletons at 4 years, and 20.3 and 20.0 in. for male and female mature singletons,

giving an excess height increment of 1 in. in the premature group. Likewise, increments for male and female twins who were $5\frac{1}{2}$ lb. or less at birth are 21.1 and 20.7 in. respectively and for twins over $5\frac{1}{2}$ lb., 20.3 and 20.1 inches.

At 4 years boys are approximately 0.5 in. taller than girls, in both premature and mature groups, as they were at birth.

The Effect of Environment on Rate of Growth

The analysis of weight and height measurements at 2 years showed that rate of growth was related to such environmental factors as maternal efficiency, diet and illness, the effect being more marked in those who were prematurely born than in mature children from similar types of home.

Maternal Care. Tables 5-8 show mean weight and height increments at 4 years for singletons and twins in three birth weight groups by the estimated efficiency of their mothers. Tables 5 and 6 also give the proportion of mothers in each birth weight group who were considered to be giving the child good or very good (1), average (2), or poor (3) care. These assessments are entirely subjective, but are considered to be valid comparisons of different standards of care within the group, as the assessments have all been made by the same observer within the child's own home. Where maternal efficiency is graded 1, the children are well fed, adequately clothed, sensibly handled and enjoy a regular routine. The houses are clean and reasonably well equipped. Cases graded 2 are those where maternal care is unsatisfactory in some respects, but not markedly so, the cause usually to be found in circumstances outside the mother's control, such as inadequate housekeeping allowance, a large family of young children, an unsatisfactory husband, poor housing or poor maternal health. Where maternal care is graded 3 the home environment is obviously unsatisfactory as regards diet, cleanliness and routine. In many cases these mothers are of limited intelligence, and receive little support from their husbands.

Among singletons standards of care were markedly higher in the mature control group. Three-quarters of these mothers were considered to be giving good care, compared with about one half in the two premature groups. The average standard of care was lower for twins in all groups, and shows little difference by birth weight. The reason appears to be two-fold. Some mothers who could manage a single baby satisfactorily are less able to cope with twins. This was felt to be the case especially with young mothers, following a first or second pregnancy. There was also an excess of older mothers

TABLE 5
MEAN FOUR-YEAR WEIGHT INCREMENTS BY MATERNAL CARE (SINGLETONS)

Maternal Care	Birth Weight						Difference A-C lb. oz.	
	A (4 lb. 8 oz. and under)		B (4 lb. 9 oz.-5 lb. 8 oz.)		C (5 lb. 9 oz. and over)			
	Receiving Different Care (%)	Weight Increment lb. oz.	Receiving Different Care (%)	Weight Increment lb. oz.	Receiving Different Care (%)	Weight Increment lb. oz.		
1	56.2	30 2	51.9	28 11	73.8	29 6	+	12
2	29.2	28 6	26.0	27 0	14.1	26 9	+ 1	13
3	14.6	27 2	22.1	26 3	12.1	27 10	-	8
Difference 1-3		3 0		2 8		1 12		
No. of Cases	89		131		109			

TABLE 6
MEAN FOUR-YEAR WEIGHT INCREMENTS BY MATERNAL CARE (TWINS)

Maternal Care	Birth Weight						Difference A-C lb. oz.
	A (4 lb. 8 oz. and under)		B (4 lb. 9 oz.-5 lb. 8 oz.)		C (5 lb. 9 oz. and over)		
	Receiving Different Care (%)	Weight Increment lb. oz.	Receiving Different Care (%)	Weight Increment lb. oz.	Receiving Different Care (%)	Weight Increment lb. oz.	
1	49·0	29 5	44·5	28 14	51·3	29 4	+ 1
2	20·8	27 6	33·3	26 5	17·9	30 14	- 3 8
3	30·2	25 10	22·2	26 13	30·8	27 15	- 2 5
Difference 1-3		3 11		2 1		1 5	
No. of Cases	53		54		78		

TABLE 7
MEAN FOUR-YEAR HEIGHT INCREMENTS BY MATERNAL CARE (SINGLETONS)

Maternal Care	Mean Height Increment (in.)			Difference A-C
	Birth Weight			
	A 4 lb. 8 oz. and under	B 4 lb. 9 oz.- 5 lb. 8 oz.	C 5 lb. 9 oz. and over	
1	21.9	21.2	20.5	1.4
2	22.0	20.5	19.5	2.5
3	20.7	20.1	19.1	1.6
Difference 1-3	1.2	1.1	1.4	

TABLE 8
MEAN FOUR-YEAR HEIGHT INCREMENTS BY MATERNAL CARE (TWINS)

Maternal Care	Mean Height Increment (in.)			Difference A-C
	Birth Weight			
	A 4 lb. 8 oz. and under	B 4 lb. 9 oz.- 5 lb. 8 oz.	C 5 lb. 9 oz. and over	
1	21.9	21.3	20.5	1.4
2	21.6	20.3	20.8	0.8
3	19.7	19.7	19.5	0.2
Difference 1-3	2.2	1.6	1.0	

with four or more other children in the twins' group, as compared with singletons. This was particularly so in those twins over 5½ lb. at birth, and accounts for the lower average standard of care of maturely born twins. It was shown in a previous paper (Drillien, 1959b) that in general maternal care deteriorated with increasing size of family.

Mean weight increments of singletons decrease with declining maternal standards in all birth weight groups, the effect being most noticeable in those smallest at birth. There is a difference of 3 lb. in mean four-year weight increment between those

children receiving the best and worst care who were smallest at birth, compared with 1¾ lb. in the mature control group.

Weight increments are biggest for those who were 4½ lb. or less at birth, except for those receiving the poorest care, and tend to be smallest in the 4½-5½ lb. birth weight group.

In the twin group lower mean weight increments are also recorded for less satisfactory care, especially in those who were 4½ lb. or less at birth. Here the difference between those receiving the best and worst care is 3¾ lb. Only in the group receiving the best

care are increments highest for those smallest at birth. Increments are approximately equal for twins and singletons receiving like care whose birth weights were over $4\frac{1}{2}$ lb., but in the smallest birth weight group increments for twins are less for all grades of care.

Mean height increments are also related to maternal care for both singletons and twins, the effect being most marked in those twins smallest at birth. Here there is a difference of 2.2 in. between those receiving the best and worst care. In all maternal care groups mean height increment increases with decreasing birth weight, this being more noticeable for singletons.

From these figures it appears that weight and height at 4 years are related both to birth weight and maternal care. The effect of poor maternal care is most marked in those who were smallest at birth, and affects twins more than singletons. Small prematurely born children receiving poor care tend to be not only shorter and lighter, but also under-weight for their height.

Incidence of Illness. The incidence of medical illness during the third and fourth years of life has been scored to take into account the number of disease incidents and the severity of these episodes. The reporting of illness is not thought to be as accurate during this age period as it was in the first two years of life. In most cases the interval between visits has been 12 months instead of six. There is probably considerable under-reporting in the poorest homes, especially of less serious conditions. After the age of 2 the poorer types of mothers are more likely to ignore such episodes as sore throats, diarrhoea, and feverish colds, whereas the mother from a superior working class or middle class home continues to seek medical aid. Incidence of illness has been graded as (1) little or none, (2) some, and (3) more frequent.

Tables 9 and 10 give mean weight and height increments at 4 years for these illness grades, by birth weight, in singletons and twins. The reported incidence of illness was approximately the same for singletons of all birth weights and twins over $4\frac{1}{2}$ lb. at birth. The smallest twins had a significantly higher incidence of frequent illness, being more than twice as high (36%) than for singletons of like birth weight (17%). Smaller weight and height increments are recorded for singletons who were $4\frac{1}{2}$ lb. or less at birth and all birth weight groups of twins, as incidence of illness increases. In singleton groups over $4\frac{1}{2}$ lb. at birth recorded increments at 4 years were higher for those who were said to have had more illness, though

the differences between illness grades are not significant.

Incidence of illness is correlated with maternal care, although not to the same extent as in the first two years of life, and it is likely that the apparent effect of illness is a reflection of the child's total environment. Compared with the age period from birth to 2 years, fewer children suffered constant ill health.

In the Newcastle study (Miller *et al.*, 1960) a significant correlation was found between stature at 3 years and the incidence of severe respiratory infections, although this was practically limited to children having four or more illnesses. These authors point out that the incidence of severe respiratory disease is itself correlated strongly with adverse environmental conditions, and suggest that a common factor is likely to explain both the small stature and increased frequency of illness.

In the two-year growth analysis (Drillien, 1958b) it was shown that prematurely born singletons from the best environment had very nearly caught up, both in weight and height, with the total mature group by 2 years, but twins who were $4\frac{1}{2}$ lb. or less at birth were still substantially behind those over this birth weight in both weight and height. Tables 11 and 12 give mean weights and heights and weight and height increments at 4 years for 'selected' prematures (i.e. those receiving the best care and having no more than a moderate amount of illness), as compared with 'selected' maturely born children and the total control group, for singletons and twins. The mean height of the mothers is also given. At 4 years the 'selected' prematurely born are still lighter and shorter than the maturely born. The difference in weight of singletons is greater than at 2 years. The smallest prematures are now 2 lb. lighter than the mature controls, compared with 14 oz. at 2 years. Those between $4\frac{1}{2}$ and $5\frac{1}{2}$ lb., are nearly 3 lb. lighter than the matures. It is noticeable that the average height of mothers in this group is approximately 1 in. less than for the other two groups. In a previous study of the social aetiology of prematurity (Drillien, 1957) it was shown that, whereas, in the mature control group, height of mother was positively correlated with weight of baby, in the premature group the relationship was reversed. It was concluded that babies classified as premature on a weight basis were a mixture of two categories, early and small full-term. The mothers of the latter were significantly shorter than those with early babies. In height the prematurely born are about 1 in. shorter than the control group, which is rather more than at 2 years. The differences at 4 years between twins who were

TABLE 9
MEAN FOUR-YEAR WEIGHT AND HEIGHT INCREMENTS (SINGLETONS) BY FREQUENCY OF ILLNESS

Illness Grade	Birth Weight					
	4 lb. 8 oz. and under		4 lb. 9 oz.-5 lb. 8 oz.		5 lb. 9 oz. and over	
	Weight Increment lb. oz.	Height Increment (in.)	Weight Increment lb. oz.	Height Increment (in.)	Weight Increment lb. oz.	Height Increment (in.)
1	30 9	21.5	27 7	20.8	28 7	20.2
2	28 14	21.6	27 15	20.7	28 1	19.9
3	27 1	20.9	28 13	20.9	29 9	20.5
Difference 1-3	3 8	0.6	-1 6	-0.1	-1 2	-0.3

TABLE 10
MEAN FOUR-YEAR WEIGHT AND HEIGHT INCREMENTS (TWINS) BY FREQUENCY OF ILLNESS

Illness Grade	Birth Weight					
	4 lb. 8 oz. and under		4 lb. 9 oz.-5 lb. 8 oz.		5 lb. 9 oz. and over	
	Weight Increment lb. oz.	Height Increment (in.)	Weight Increment lb. oz.	Height Increment (in.)	Weight Increment lb. oz.	Height Increment (in.)
1	29 4	22.2	28 4	21.1	29 14	20.4
2	28 10	21.8	27 12	20.9	29 1	20.4
3	25 10	19.6	25 12	19.1	28 13	19.8
Difference 1-3	3 10	2.6	2 8	2.0	1 1	0.6

TABLE 11
MEAN FOUR-YEAR WEIGHT AND HEIGHT INCREMENTS FOR 'SELECTED' PREMATURES AND MATURE CONTROLS (SINGLETONS)

Mean	Selected			Total Mature
	Birth Weight			
	4 lb. 8 oz. and under	4 lb. 9 oz.- 5 lb. 8 oz.	5 lb. 9 oz. and over	
Birth weight ..	3.8	5.2	7.6	7.6
Weight at 4 years ..	34.3	33.6	36.6	36.2
Weight increment ..	30.5	28.4	29.0	28.6
Height at 4 years (in.)	39.4	39.4	40.4	40.2
Height, mothers (in.)	63.3	62.2	63.4	63.0
No. of cases ..	42	55	69	107

TABLE 12
MEAN FOUR-YEAR WEIGHT AND HEIGHT INCREMENTS FOR 'SELECTED' PREMATURES AND MATURE CONTROLS (TWINS)

Mean	Selected			Total Mature
	Birth Weight			
	4 lb. 8 oz. and under	4 lb. 9 oz.- 5 lb. 8 oz.	5 lb. 9 oz. and over	
Birth weight	3.9	5.2	6.8	6.6
Weight at 4 years	33.5	33.9	36.2	35.7
Weight increase	29.6	28.7	29.4	29.1
Height at 4 years (in.)	39.2	39.4	40.3	39.9
Height, Mothers (in.)	62.9	63.7	63.9	63.5
No. of cases	23	23	35	78

under or over 5½ lb. at birth are approximately the same as for singletons, although at 2 years the smallest twins were much further behind in weight and height than singletons of like birth weight.

It appears that at 4 years birth weight still has an effect on stature, and prematurely born children from the best homes are still smaller than the maturely born, even when height of mother is taken into account. Twins have overcome their disability, as compared with singletons; the smaller size of those twins who were 4½ lb. or less at birth may be attributed to the fact that the average height of the mother happens to be lower in this twin group.

The Effect of Gestational Period on Rate of Growth

At 2 years no significant correlation was found between length of gestation and weight and height increments. It might be expected that post-natal growth would be slower in those small babies born at or near term, often to mothers of small stature, but this was not demonstrable at 2 years. Douglas and Mogford (1953) failed to demonstrate any independent effect of gestation time on 4-year weight and height. However, in the Edinburgh study obvious differences had appeared by the age of 4, as shown in Table 13. In the birth weight group

TABLE 13
MEAN FOUR-YEAR WEIGHTS AND HEIGHTS FOR
CHILDREN $5\frac{1}{2}$ LB. OR LESS AT BIRTH,
BY GESTATION PERIOD

Mean	Gestation (weeks)	Birth weight	
		4 lb. 8 oz. and under	4 lb. 9 oz.- 5 lb. 8 oz.
Weight at 4 years ..	37 or less 38 or more	34.5 33.8	34.9 32.5
Height at 4 years (in.) ..	37 or less 38 or more	39.2 39.6	39.7 39.0
Height, mothers (in.) ..	37 or less 38 or more	63.3 63.4	62.2 62.2

$4\frac{1}{2}$ lb. or less, 83% of mothers gave the gestation time as being 37 weeks or less. In the group $4\frac{1}{2}$ - $5\frac{1}{2}$ lb. the estimated gestation time was 38 weeks or more in 55% of cases. These small full-term babies were $2\frac{1}{2}$ lb. lighter at 4 years and 0.75 in. shorter than babies of like birth weight whose estimated gestation time was less than 38 weeks.

The Effect of Parental Heights

In the 2-year growth analysis it was found that rate of growth was affected not only by environmental factors but also by genetic factors, as deduced from parental heights. Genetic and environmental factors were intercorrelated to quite a high degree, and the technique of correlation and regression analysis was used to disentangle the relative contribution of different factors. It was then found that genetic and environmental factors were of approximately equal importance in their influence on growth, whether measured by height or weight increment at 2 years.

Table 14 gives first order correlation coefficients

between weight and height increments at 4 years and maternal care, and between these increments and maternal height, for singletons and twins in different birth weight groups, with the levels of significance of these coefficients.

In general, the correlation coefficients between rate of growth and the representative environmental and genetic factors are higher at 4 years than at 2 years, the highest correlations being recorded for those who were smallest at birth, and being higher for twins who were $5\frac{1}{2}$ lb. or less at birth than for singletons of like birth weight. As at 2 years, correlations between increments and maternal height are rather higher than those between increments and maternal care. However, it should be remembered that maternal heights are themselves environmentally determined in part. Baird and Illsley (1953) have pointed out that a mother's height and physical grade are directly associated with her pre-marital environment. Baird (1959) also demonstrated an association between small stature and under-average intelligence in mothers.

Table 15 gives the proportion of mothers who were short, medium, and tall in each maternal care group. In the group giving the poorest care more than half the mothers were 5 ft. 1 in. or less compared with less than a quarter of small mothers in the best care group. Table 16 gives mean weight and height increments at 4 years for children born to short, medium, and tall mothers in the three care groups, and demonstrates how rate of growth increases with height of mother, for all grades of care, and decreases with declining standards of care, for all heights of mother. The differences are greater by height of mother, but this does not neces-

TABLE 14
CORRELATION COEFFICIENTS BETWEEN FOUR-YEAR WEIGHT AND HEIGHT INCREMENTS AND
MATERNAL CARE AND MATERNAL HEIGHT, FOR SINGLETONS AND TWINS

	Birth Weight lb. oz.	Correlation Coefficients Between Weight Increment and:			
		Maternal Grade	p	Maternal Height	p
Singletons	4.8 and under 4.9-5.8 5.9 and over	0.3045 0.1905 0.2144	<0.01 <0.05 <0.05	0.5215 0.3768 0.1808	<0.001 <0.01 not significant
Twins	4.8 and under 4.9-5.8 5.9 and over	0.4483 0.3028 0.1411	<0.001 <0.05 not significant	0.4517 0.4919 0.3661	<0.001 <0.001 <0.01
	Birth Weight lb. oz.	Correlation Coefficients Between Height Increment and:			
		Maternal Grade	p	Maternal Height	p
Singletons	4.8 and under 4.9-5.8 5.9 and over	0.2504 0.2939 0.1970	<0.02 <0.001 <0.05	0.5595 0.2627 0.3688	<0.001 <0.01 <0.001
Twins	4.8 and under 4.9-5.8 5.9 and over	0.4461 0.3742 0.2698	<0.001 <0.01 <0.02	0.4561 0.2848 0.2520	<0.001 >0.05 >0.02

TABLE 15
MATERNAL CARE BY HEIGHT OF MOTHER

Maternal Care	Height of Mother						Total	
	5 ft. 1 in. and under		5 ft. 2 in. and 5 ft. 3 in.		5 ft. 4 in. and over			
	No.	%	No.	%	No.	%	No.	%
1	67	23.5	88	30.9	130	45.6	285	100.0
2	46	40.0	39	33.9	30	26.1	115	100.0
3	56	54.4	23	22.3	24	23.3	103	100.0

TABLE 16
MEAN FOUR-YEAR WEIGHT AND HEIGHT INCREMENTS BY MATERNAL CARE AND MATERNAL HEIGHT

Maternal Care	Maternal Height						Difference C-A	
	A 5 ft. 1 in. and under		B 5 ft. 2 in.-5 ft. 3 in.		C 5 ft. 4 in. and over			
	Mean		Mean		Mean		Weight Increment lb. oz.	Height Increment (in.)
	Weight Increment lb. oz.	Height Increment (in.)	Weight Increment lb. oz.	Height Increment (in.)	Weight Increment lb. oz.	Height Increment (in.)		
1	27 10	20.3	29 6	21.0	30 3	21.7	2 9	1.4
2	26 2	20.3	28 5	20.8	28 12	21.6	2 10	1.3
3	25 13	19.3	27 15	20.3	28 8	20.4	2 11	1.1
Difference 1-3	1 13	1.0	1 7	0.7	1 11	1.3		

sarily mean that rate of growth is affected more by parental height than by environment. Height can be measured accurately, whereas even the best estimate of maternal care must be considerably less accurate.

Heights of fathers show similar correlations with rate of growth, although these tend to be lower than those for maternal height. This would be expected as the fathers were not measured but merely asked to state their height, and these estimates are likely to be less accurate. It was shown in the previous paper on growth that father's height is quite highly correlated with mother's height, and also with maternal efficiency.

The Effect of Feeding Problems on Rate of Growth

Reference has been made in a previous paper (Drillien, 1959c) to feeding problems in the first two years of life, defined as refusal to eat or excessive faddiness, lasting for three to six months or longer. No difference could be demonstrated in weight or height increments at 2 years between those who had or had not exhibited feeding problems, even when the refusal to eat had been prolonged.

During the age period 2 to 4 years about 16% of the total group exhibited feeding problems lasting for six months or longer (the incidence was 15% during the first two years of life). At 4 years some obvious difference was found, particularly in weight increment, between those who had or had not

exhibited feeding problems as shown in Table 17. Mean increments are given, by maternal grade, as the incidence varies with grade, being highest with those mothers giving the best maternal care. The question of feeding problems will be considered more fully in a later paper.

Summary

A statistical analysis is presented of a study of physical growth in the age period 2 to 4 years, in a group of 500 children of varying birth weight. The following conclusions were reached:

At 4 years mean weights for the total premature group and mature group are closely related to birth weight for singleton births.

In the premature group the highest weight increments are recorded for those who were smallest at birth, and the lowest for those who were between $4\frac{1}{2}$ and $5\frac{1}{2}$ lb.

TABLE 17
MEAN FOUR-YEAR WEIGHT AND HEIGHT INCREMENTS
FOR THOSE WITH AND WITHOUT FOOD FADS

Maternal Grade	Food Fads			
	With		Without	
	Weight Increment lb. oz.	Height Increment (in.)	Weight Increment lb. oz.	Height Increment (in.)
1	27 2	20.5	29 9	21.3
2	27 8	20.8	27 15	21.6
3	25 12	20.3	27 3	19.8

For twin births significantly smaller weight increments are recorded for those less than $5\frac{1}{2}$ lb. at birth, compared with those over this weight. In all birth weight groups lower increments are recorded for twins than for singletons.

Larger weight increments are recorded for both singleton and twin boys, as compared with girls. This is largely accounted for by excess male weight increments in the first six months of life.

At 4 years the prematurely born are still between 1 and $1\frac{1}{2}$ in. shorter than the mature controls, although increments for all birth weight groups of singletons and twins are inversely related to birth weight. Height increments are approximately equal for boys and girls. At 4 years the prematurely born tend to be lighter and shorter than the controls, and also underweight for their height.

The following different factors have been shown to have an effect on rate of growth:

(a) Maternal care. Lower weight and height increments are recorded in all birth weight groups as standards of maternal care deteriorate. The effect of poor care is most marked on those who were smallest at birth and on twins of all birth weights.

(b) Morbidity. Smaller increments are recorded with increasing frequency of illness for singletons who were less than $4\frac{1}{2}$ lb. at birth and for twins. Recorded incidence of illness is considered to be a less sensitive index of total environment during the 2 to 4 year age period than it was during the first two years of life. Those prematures receiving the best care and having little illness show larger growth increments, but are still behind the mature controls at 4 years.

(c) Gestation period. Those children of birth weight $4\frac{1}{2}$ - $5\frac{1}{2}$ lb. who were born at or near term were both shorter and lighter at 4 years than children

of like birth weight who were premature by gestation as well as by weight. The average height of mother was 1 in. less for children between $4\frac{1}{2}$ and $5\frac{1}{2}$ lb. than for children below and above this birth weight, smaller mothers being more likely to have small babies at term.

(d) Parental height. Rates of growth are significantly correlated with parental heights, as well as with maternal care. Environmental and genetic factors are considered to be of about equal importance in their effect on rate of growth.

(e) Feeding problems. Prolonged feeding problems during the age period 2 to 4 years appeared to have a definite effect on weight and a lesser effect on height.

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