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FACTORS INFLUENCING THE HEIGHT OF SEVEN YEAR OLD CHILDREN—RESULTS FROM THE NATIONAL CHILD DEVELOPMENT STUDY

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IN 1958 a study was carried out of every baby in England, Wales and Scotland born during the week of 3rd-9th March (Butler and Bonham, 1963; Butler and Alberman, 1969). In 1965 when these children were seven years old they were re-traced and information was gathered on their medical, sociological and educational status. A preliminary analysis of the 1965 information is given in Kellmer Pringle, Butler and Davie (1966). The National Child Development Study is currently analysing the 1965 information in detail, and particularly the relationships between this information and the data collected at birth.

The 1958 study collected information on 16,994 singleton births which was estimated to be about 98% of all births in the period. Of those children who survived to seven years and who remained in Britain, 14,848 or 89% were traced in 1965.

The composition of this Sample has been studied in several ways. Most importantly the social class distribution of the "untraced" children is different from that of the "traced" children, there being relatively more untraced children in Social Classes 1 and 5, but these differences are small and the major conclusions presented here make allowance for social class. The composition of this sample has also been examined by comparing the mean heights at each month of age between seven and eight years, with the current British Standards (Tanner, Whitehouse and Takaishi 1966). There is no significant departure from the 50th percentile for boys, but some evidence for a higher mean height of about 0.3 cm for the girls.

METHODS

The heights were measured during a medical examination by a school medical officer or nurse using whatever equipment was available. They were asked simply to measure the "child's height to the nearest inch." The information on social class, and on the number of younger siblings,

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was collected at seven years of age during an interview with an adult responsible for the child, usually the mother. Birthweight was measured at birth, maternal height at birth or during the pregnancy and the information on length of gestation, parity, mother's age and smoking habit was collected by questionnaire at the time of birth.

Only those children, a total of 13,127, who were measured during the period April 1965-December 1965 are included in this analysis. The date of measurement is recorded to the nearest month.

RESULTS

The present analysis is confined to singleton born children only, twins having somewhat different growth patterns. Eight perinatal and maternal variables have been used, namely Parity, Birthweight, Length of Gestation, Maternal Age, Maternal Height, Maternal Smoking Habits during Pregnancy, social class, and the number of younger siblings. Allowance has been made for the sex and age of child at measurement.

In most previous studies, the sexes have been analysed separately, as it was felt that the relationships between height and the other factors might be different for boys and girls. But there appears to have been little attempt to test this assumption by examining the statistical interactions of sex with variables such as social class and parity. In the present data the interaction of sex with each of the variables has been examined and in no case is it significant. In all analyses therefore, the sexes have been pooled, allowing only for an average height difference between boys and girls. This difference is 0.77 cm with a standard error of 0.12 cm.

Since the growth rate between 7.0 and 8.0 years is fairly constant, an allowance has been made for the age of the child at measurement by the fitting of a linear regression coefficient in all analyses. This coefficient is 5.4 cm per year with a standard error of 0.4 cm.

These estimates of the sex difference and the rate of growth change slightly when further variables are allowed for in the analysis. Tables 1-5 analyse the separate effects on child's height of smoking during pregnancy, mother's height, social class, birthweight, and gestation and parity. Interest also lies in discovering something concerning the aetiological relationships, and it is necessary to partial out or make allowance for various "disturbing" factors such as social class, which, because it is related to both height and, say, smoking during pregnancy, may be the primary variable which "causes" a relationship between height

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and smoking during pregnancy. Table 6 presents an analysis of covariance where the following variables are analysed jointly: smoking during pregnancy, mother's height, social class, parity, number of younger siblings, age of mother at birth of child, birthweight and gestation. After allowing for the other variables this analysis enables the "partial" effects of any one variable to be examined. It could be used to examine many more hypotheses than have in fact been chosen, but it may be noted that all the "partial" effects are significant save that of gestation length, which implies that all the remaining factors make a contribution to height at seven years. The smaller number of children available for this analysis is due to the fact that only those cases with information on all variables could be included.

The adequacy of the "main effects" model used in Table 6 has been tested by the examination of some of the most important statistical interactions, and it is found that none are significant.

Social Class

Social class differences have been established by a number of studies, and it is necessary to quote only Douglas (1964), who finds a difference of about 2.8 cm between "upper middle class" and "lower working class" children at age 7.

Table 1 shows the effects of Social Class on height at seven years. These results agree very closely with Douglas. There is an average difference of 3.3 cm between children from Social Class 1 or 2 and those from Social Class 5.

There is also a difference in birthweight between children of different social classes, but when allowance is made for maternal height this becomes non-significant (Butler and Alberman 1969). At age seven the effect of social class on height persists (though much reduced in amount) when allowance is made for mother's height and the other factors (Table 6). The adjusted difference in height between a social class 1 or 2 child and a social class 5 child is 1.3 cm. As this difference is estimated after allowing for the effects of parity and the number of subsequent children, it reflects other influences related to social class. Some of this difference might be accounted for by father's height. Figure 1 shows the effects of social class on height at seven, for each of three parity groupings. The average height of children of parity 3 or more does not show the same relationship with social class as those with parity less than 3. This "interaction" is statistically significant, but

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TABLE 1

Analysis of Childrens' Stature by Social Class
Dependent variable is Child's Stature in cm
Sample Size = 12362

Independent variables are:

1. Age of child in years
2. Social Class at 7 years. Five categories (Registrar General 1960) 1 or 2, 3 non-manual, 3 manual, 4, 5.
3. Sex. Boys, Girls.

Main Effects Model. Fitted Constants and Analysis of Variance Table
Chi square values are adjusted for the other factors

Source		Fitted Constant	Standard Error	D. F.	χ^2
Overall Constant		120.1			
Age Coefficient (gain per year measured about 7.0 years)		4.95	0.41	1	148.3 ***
Sex	Boys-Girls	0.87	0.11	1	58.2 ***
Social Class	1 or 2	1.51			
	3 non-manual	0.93			
	3 manual	−0.14		4	242.4 ***
	4	−0.49			
	5	−1.81			

Residual Mean Square = 40.57

Sex Interaction

Constants were fitted for the interaction of sex and social class

Test for interaction $\chi^2 = 7.4$ D. F. = 4

Significance levels
*** P<0.001
** 0.001<P<0.01
* 0.01 <P<0.05
Otherwise 0.05 <P

Since the degrees of freedom for the residual mean square are large, tests of significance are expressed, for simplicitly, in terms of the χ^2 distribution rather than the F distribution.

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becomes non-significant when all the other factors are allowed for (Table 6).

Parity and Number of Younger Siblings

It is well established that children with many siblings tend to be shorter than children with few. Among 8-year-old London schoolchildren in 1959 (Scott 1961) there were differences of about 3 cm, for both boys and girls, between those from 1-child families and those from

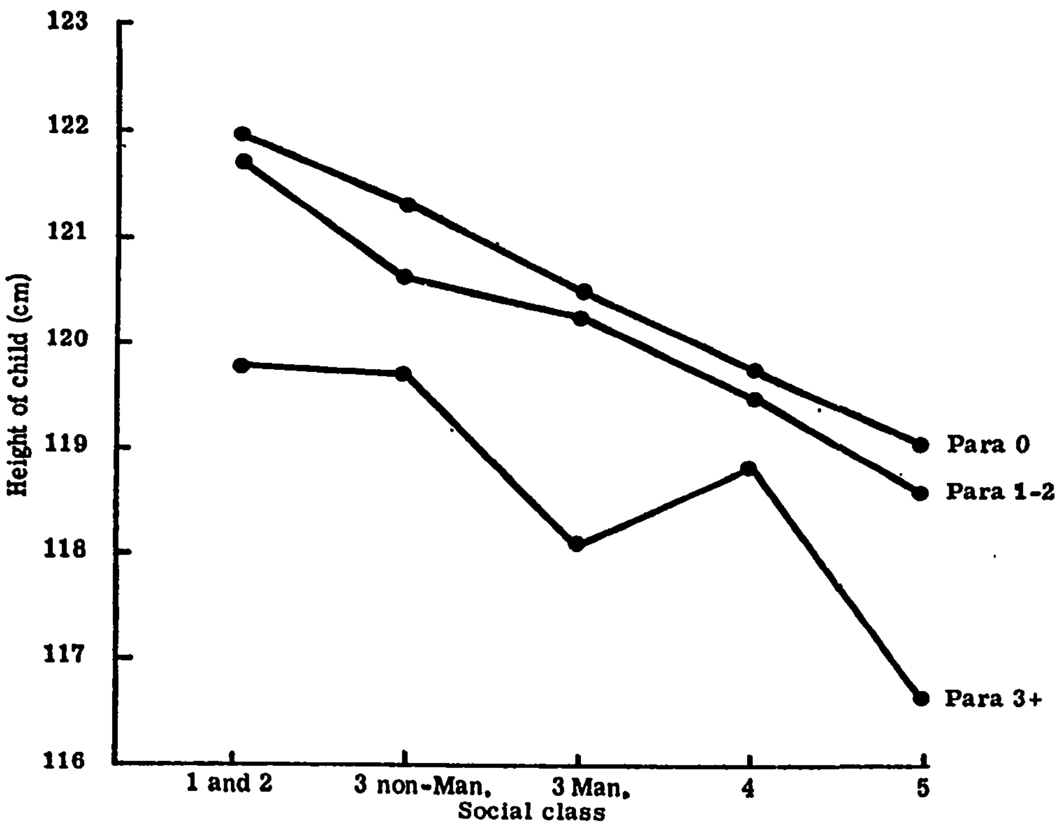

FIG. 1. HEIGHT OF CHILD AT 7.0 YRS. BY SOCIAL CLASS AND PARITY. MEAN OF BOYS AND GIRLS.

families with 5 or more children. Grant (1964) showed a similar difference among 6-year-old children. It is also well known that later-born children tend to be shorter than their elder sibs. Douglas (1958) found a difference of about 1.5 cm at 4½ years between first born and later-born children. Needless to say, these two facts are closely related, since, in a population of children at a given age, those with high birth

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order will tend to come from larger families. In the normal family situation, the effects of birth order and family size cannot be separated, since, by definition, the eldest child enters a smaller family than a later born child who (except in cases of children having been removed by death etc.), enters a family with at least one additional (earlier born) child. It is meaningful therefore, at a given age, only to separate the effect of younger siblings from that of birth order. Instead of studying just the number in the family, it is useful to split this into these two variables (strictly speaking, considering only those children who still remain in the family), in order to obtain a more detailed understanding of the mechanisms involved. There do not appear to be any published studies which attempt to do this.

Grant (1964) compares younger with older sibs at the same age within the same families, for each of several family sizes, by measuring the younger sib when he or she reaches the age at which the older sib was measured. Although this method does have the advantage of making allowance for the variation between families, for the reasons outlined above it does not separate the effect of birth order from size of family. Grant concludes that the tallest sibs are the later born ones, who are in fact those with fewer younger siblings.

In the present analysis parity (which includes stillbirths) has been used instead of the number of surviving earlier born children, so that the total number of children cannot be derived exactly from the two variables used. In some ways however, parity is a more interesting variable to study than surviving older children, and, in particular, allows comparison with perinatal information which normally uses parity when comparing birthweights etc.

Table 2 and Figure 1 show the effects of Parity on height at 7 years. These results agree very closely with those of Douglas and others. There is an average difference of 2.3 cm between first born children and 4th or later born children.

Since the child's height, the number of younger siblings and parity, are all associated with social class and maternal age, allowance has been made for these in the analysis. Additionally, allowance has been made for maternal height and smoking during pregnancy as possible disturbing variables, and because of their known associations with height.

The results (Table 6) are very similar whether or not birthweight and gestation are allowed for, and the analysis which does not make allowance for birthweight and gestation, will be described. This is, there-

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fore, an attempt to isolate the direct biological effects of parity and the number of younger siblings.

At seven years, first born children are 2.8 cm taller than 4th or later born children for a given number of younger siblings. At a given parity, those children with no younger siblings are 1.1 cm taller than those with two or more younger siblings. Thus, the effects of being a later child and having younger siblings (for a given age of mother etc.) combine

TABLE 2

Analysis of Children's Stature by Parity

Dependent variable is Child's Stature in cm

Sample Size = 12381

Independent variables are:

1. Age of child in years.
2. Parity. Three categories: 0, 1 or 2, 3 or over.
3. Sex. Boys, Girls.

Main Effects Model. Fitted Constants and Analysis of Variance Table

Chi square values are adjusted for the other factors

Source		Fitted Constant	Standard Error	D. F.	χ^2
Overall Constant		119.8			
Age Coefficient (gain per year measured about 7.0 years)		5.27	0.49	1	116.5 ***
Sex	Boys-Girls	0.89	0.12	1	53.5 ***
Parity	0	0.90			
	1 or 2	0.50		2	188.0 ***
	3 or over	−1.40			

Residual Mean Square = 41.29

Sex Interaction

Constants were fitted for the interaction of sex and parity.

Test for interaction $\chi^2 = 0.1$ D. F. = 2

For an explanation of the conventions used in this table see Table 1.

to decrease height, so that for example, an only child is 3.9 cm taller than a child from a household with 3 or more previous live births and two or more younger siblings. This difference is of the same order as that found by Scott (1961) for the total number of siblings, although

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parity is only approximately equivalent to the number of surviving older children.

Mother's Height

A topic which has received much attention is the relationship between the height of the child and the height of its parents. Interest has been concentrated on two aspects; first the extent to which parental height accounts for differences in childrens' heights between socio-economic groups, and second, the sex difference in the correlations of child's height with parents' height. The first question has received less attention than the second. Douglas (1958) states that Maternal height accounts for very little (about 6%) of the differences between social classes at age 4½. However it should be noted that many of the mothers in that survey were only asked for their height and not measured, so that the correlations etc, will tend to be under-estimates. The parent-child correlations increase fairly rapidly from birth until about 2 years of age, with little change from then until puberty (Tanner, Goldstein and Whitehouse 1970). There is considerable disagreement between studies as to the actual values of the correlation coefficients, average values ranging from 0.3 to 0.5 at ages after 3 years. In particular there is disagreement about whether the parent-child correlations in the same-sex case (i. e. Mother-Daughter and Father-Son) are higher than those in the unlike-sex case. Evidence in favour of a difference has come largely from longitudinal studies with very accurate measurements but with small (less than 100) numbers of children (Bayley, 1954; Thomson, 1955; Tanner and Israelsohn, 1963). Other longitudinal studies however, also with small numbers of children (Hewitt, 1957; Kagan and Moss, 1959) show only very small differences, if any. Livson, McNeill and Thomas (1962) pool data from four of the above studies with further data of their own and find small and non-significant differences at ages up to 7 years. At age 7 they find an average mother-son correlation of 0.40 and an average mother-daughter correlation of 0.48. Douglas (personal communication) finds a mother-son correlation of 0.33 and a mother-daughter correlation of 0.36 at age 7, the difference being non-significant. More recent data obtained from five European Growth Studies (Tanner, Goldstein and Whitehouse 1970) show no significant differences between Mother-Son and Mother-Daughter correlations between 2 and 9 years. At 7 years the correlations are both 0.44.

Table 3 shows the regression and correlation coefficients of child's height on mother's height. The correlation coefficient is 0.33 for boys

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and 0.32 for girls. These values agree very closely with those of Douglas, but they are somewhat smaller than the values found in other studies. One explanation for this may lie in the greater variability of the present measurements, which tends to reduce the correlation estimates. Assuming

TABLE 3

Analysis of Childrens' Stature by Maternal Stature
Dependent variable is Child's Stature in cm
Sample Size = 11931

Independent variables are:
1. Age of child in years
2. Maternal Stature in centimetres
3. Sex. Boyr Girls.

Main Effects Model. Fitted Constants and Analysis of Variance Table
Chi square values are adjusted for the other factors

Source		Fitted Constant	Standard Error	D. F.	χ^2
Overall Constant		119.34			
Age Coefficient (gain per year measured about 7.0 years)		5.21	0.40	1	171.7 ***
Sex	Boys-Girls	0.80	0.11	1	51.0 ***
Maternal Stature Coefficient (Measured about mean = 161.3)		0.33	0.0088	1	1423.6 ***

Residual Mean Square = 36.99

Sex Interaction
Separate regression coefficients were fitted for each sex.
Test equality of regression coefficients $\chi^2 = 0.1$ D. F. = 1
Partial correlation, allowing for age of child, of maternal stature with child's stature,
Girls = 0.323
Boys = 0.331
Large sample Test for difference $\chi^2 = 0.2$ D. F. = 1

For an explanation of the conventions used in this table see Table 1.

a fairly large between-measurer standard deviation of 2 cm for both the maternal and child measurements, an attenuation correction gives estimated true values of 0.36 and 0.35 which are closer to the other published

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data. There is, however, no evidence for a difference between the mother-son and mother-daughter correlations, thus confirming the recent findings of Douglas and Tanner et al.

The regression coefficient is 0.33 cm per cm of mother's height. This is reduced to 0.27 when allowance is made for all the other variables (Table 6).

Birthweight and Gestation

In the perinatal period, the birthweight and length of gestation of the baby are associated with mortality and morbidity. Table 4 shows

TABLE 4

Analysis of Childrens' Stature by Birthweight and Gestation

Dependent variable is Child's Stature in cm

Sample Size = 10780

Independent variables are:

1. Age of child in years
2. Birthweight
3. Gestation. Three categories:
   Less than 38 weeks, 38-42 weeks, over 42 weeks.
4. Sex. Boys, Girls.

Main Effects Model. Fitted Constants and Analysis of Variance Table

Chi square values are adjusted for the other factors

Source		Fitted Constant	Standard Error	D. F.	χ^2
Overall Constant		120.10			
Age Coefficient (gain per year measured about 7.0 years)		5.07	0.43	1	138.8 ***
Sex	Boys-Girls	0.42	0.12	1	11.7 ***
Birthweight Coefficient (gain per gram measured about mean birthweight = 3363 gms)		0.0028	0.00012	1	496.5 ***
Gestation	Less than 38 weeks	0.57		2	10.7 **
	38-42 wks	0.18			
	Over 42 wks	—0.75			

Residual Mean Square = 39.13

Birthweight, Gestation Interaction

Separate regression coefficients for birthweight were fitted for each gestation group.

Test Gestation effect $\chi^2 = 11.8$ D. F. = 2 **

Test for equality of birthweight coefficients $\chi^2 = 9.9$ D. F. = 2 **

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Gestation Group	*Fitted Constants*	*Birthweight Coefficients* (about 3363 gms)
less than 38 weeks	0.24	.0017
38-42 weeks	0.30	.0029
over 42 weeks	—0.54	.0027

Interaction of Sex and Gestation
Constants were fitted for the sex × gestation interaction
Test for interaction $\chi^2 = 0.6$ D. F. = 2

Interaction of Sex and Birthweight
Separate regression coefficients for birthweight were fitted for each sex
Test for interaction $\chi^2 = 0.1$ D. F. = 1

Analysis of Gestation Alone
Fitted constants after allowing for Sex and Age. Main effects model.

less than 38 weeks	—0.55
38-42 weeks	0.56
over 42 weeks	—0.01

For an explanation of the conventions used in this table see Table 1.

the joint effect of birthweight and gestation on height at 7 years. Birthweight has been used as a continuous variable and length of gestation has been categorized into 3 groups; less than 38 weeks, 38-42 weeks and over 42 weeks in order to allow for a non-linear effect. Height increases with increasing birthweight but the regression coefficients for height on birthweight are different for the three gestation groups. For the under 38 week group the coefficient is smallest and for the 38-42 week group it is greatest.

Figure 2 shows the separate regression lines for height on birthweight. The line for the under 38 week group is shown over a different birthweight range from those of the other two groups, since the birthweights tend to be lower in this group. Although these relationships may be assumed linear over these ranges of birthweights, any extrapolation beyond may not be justified.

In the lower part of the birthweight range, for a given birthweight, the under 38 week group are tallest, followed by the 38-42 week group with the smallest being the over 42 week group. This result is as expected, since for a given birthweight, a short gestation indicates a larger child for his gestational age than a longer gestation. For the upper part of the birthweight range the positions of the under 38 week group and the 38-42 week group are reversed. The above explanation then fails, indicating that beyond a certain birthweight additional factors are operating.

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Thus it may be concluded that both birthweight and gestation affect height at 7 years. If a baby is born before 38 weeks then on average, for a decrease of a kilogram of birthweight, he loses about 2 cm of height

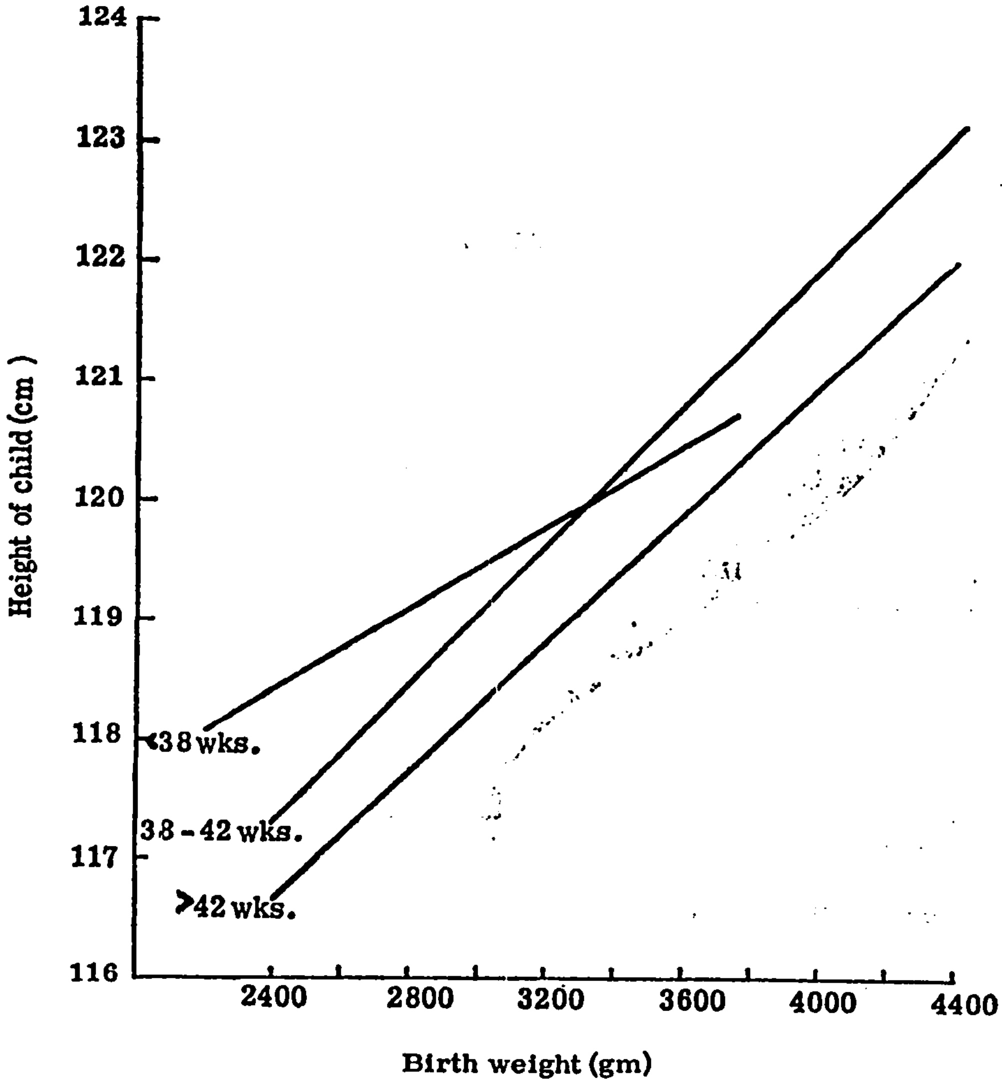

FIG. 2. HEIGHT OF CHILD AT 7.0 YRS. BY BIRTH WEIGHT AND GESTATION. MEAN OF BOYS AND GIRLS.

at 7 years and if born after 38 weeks about 3 cm for every kilogram of birthweight.

When no allowance is made for birthweight, the shortest children are those in the under 38 week group and the tallest are in the 38-42 week group, the difference being 1.1 cm.

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When allowance is made for all the other variables (Table 6) the gestation effect and the birthweight-gestation interaction become non-significant, but the birthweight effect remains. Since boys and girls have different mean birthweights, the sex difference in height is reduced after allowing for birthweight.

Smoking during Pregnancy

Table 5 and Figure 3 show that the children of mothers who smoked less than 1 cigarette a day after the 4th month of pregnancy had children

TABLE 5

Analysis of Childrens' Stature by Smoking in Pregnancy

Dependent variable is Child's Stature in cm

Sample Size = 11523

Independent variables are:

1. Age of child in years.
2. Smoking habit of mother after 4th month of pregnancy. 3 categories:
   None (less than 1 per day),
   Medium (1-10 per day),
   Heavy (over 10 per day).
3. Sex. Boys, Girls.

Main Effects Model. Fitted Constants and Analysis of Variance Table

Chi square values are adjusted for the other factors

Source		Fitted Constant	Standard Error	D. F.	χ^2
Overall Constant		119.70			
Age Coefficient (gain per year measured about 7.0 years)		5.40	0.42	1	162.5 ***
Sex	Boys-Girls	0.77	0.12	1	41.5 ***
Smoking	None	0.72		2	66.8 ***
	Medium	—0.13			
	Heavy	—0.59			

Residual Mean Square = 41.14

Sex Interaction

Constants were fitted for the interaction of sex with smoking.

Test for interaction $\chi^2 = 3.1$ D. F. = 2

For an explanation of the conventions used in this table see Table 1.

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0.9 cm taller than those who smoked up to 10 per day and this group had children 0.5 cm taller than those who smoked over 10 per day.

Table 6 shows that, after making allowance for social class, height of mother and other "nuisance" variables, there are still significant differences in height between the three smoking groups, the "non smoking" mothers having children 0.6 cm taller than the "heavy smokers." It is known (Butler and Alberman 1969) that the average difference in birthweight between these two groups is about 170 gm, and

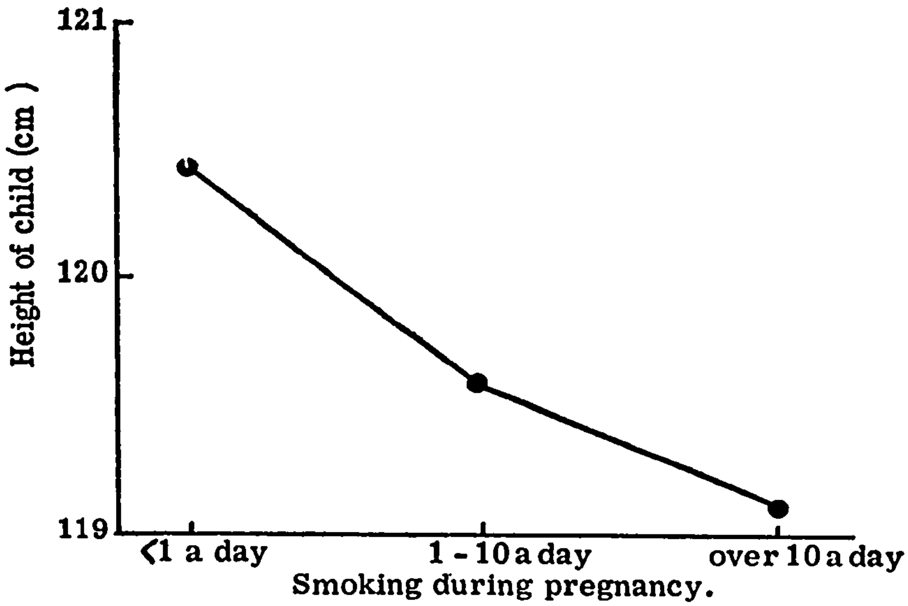

FIG. 3. HEIGHT OF CHILD AT 7.0 YRS. BY SMOKING IN PREGNANCY. MEAN OF BOYS AND GIRLS.

if birthweight is excluded from the above analysis, the difference between the two groups rises to 1.0 cm, the increase corresponding to an increase of about 170 gm in birthweight. Thus smoking during pregnancy influences height partly by lowering the birthweight and partly by an effect over and above its effect on birthweight.

Age of Mother

Table 6 shows that after allowing for the other variables, in particular for Social Class and Parity, the children of mothers who were under 25 years at the birth of the child, are on average 0.6 cm smaller than the children of mothers aged 25 or over.

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TABLE 6

Analysis of Childrens' Stature by Smoking in Pregnancy, Birthweight, Gestation, Maternal Stature, Social Class, Parity, Number of Younger Siblings, and Age of Mother

Dependent variable is Child's Stature in cm
Sample Size = 5538
The independent variables are as defined in Tables 1-6.

Main Effects Model. Fitted Constants and Analysis of Variance Table
Chi square values are adjusted for the other factors

Source		Fitted Constant	Standard Error	D. F.	χ^2
Overall Constant		118.63			
Age Coefficient (gain per year measured about 7.0 years)		4.89	0.56	1	76.3 ***
Sex	Boys-Girls	0.37	0.16	1	5.3 *
Smoking	None	0.35			c *
	Medium	—0.05		2	7.9 *
	Heavy	—0.30			
Birthweight Coefficient (gain per gram measured about mean = 3363 gms)		0.0021	0.00018	1	140.2 ***
Gestation	<38 wks	0.20			
	38-42	—0.09		2	0.8
	>42	—0.11			
Maternal Stature Coefficient (measured about mean = 161.3 cm)		0.27	0.013	1	446.9 ***
Social Class	1 or 2	0.66			
	3 non-manual	0.08			
	3 manual	0.03		4	16.2 **
	4	—0.12			
	5	—0.65			
Parity	0	1.36			
	1,2	0.12		2	108.0 ***
	3 or more	—1.48			
Number of Younger Siblings	0	0.51			
	1	0.12		2	21.2 ***
	2 or more	—0.63			
Age of Mother	<25	—0.39			
	25-34	0.23		2	11.8 **
	>34	0.16			

Residual Mean Square = 35.135
Total Variance = 42.026

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TABLE 6 (Continued)

Analysis of Childrens' Stature by Smoking in Pregnancy, Birthweight, Gestation, Maternal Stature, Social Class, Parity, Number of Younger Siblings, and Age of Mother

Interaction

Tests were made for the following interactions:

Social Class × Number of Younger Siblings	$\chi^2 = 7.8$	D. F. = 8
Social Class × Parity	$\chi^2 = 3.4$	D. F. = 8
Birthweight × Maternal Height	$\chi^2 = 1.3$	D. F. = 1
Number of Younger Siblings × Parity	$\chi^2 = 2.8$	D. F. = 4

Test Social Class × Parity interaction after fitting constants for Age, Sex, Social Class and Parity only. $\chi^2 = 17.3$ D. F. = 8 *

Fitted Constants for Parity and Number of Younger Siblings, Fitting the Above Main Effects Model Without Birthweight and Gestation

Parity	0	1.13
	1, 2	0.14
	3 or more	−1.27
Number of Younger Siblings	0	0.52
	1	0.12
	2 or more	−0.64

Fitted Constants for Smoking, Fitting the Above Main Effects Model Without Birthweight and Gestation

None	0.54
Medium	−0.09
Heavy	−0.45

For an explanation of the conventions used in this table see Table 1.

DISCUSSION

Data from the National Child Development Study have been used to quantify the effects of various factors on the height of seven year old children. Most of the evidence for the effect of Social Class and the number of children in the family comes from studies with large samples of children, and this evidence is confirmed in the present study. It is particularly interesting that there has been little if any change in Social Class differences since the comparable study of Douglas, 12 years previously, in 1953.

Previous evidence for the effect of mother's height, in particular for a sex difference in the correlation coefficient of child's height with mother's height, has come from longitudinal studies with small samples.

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This evidence has been conflicting and the present study provides no evidence for a difference between the mother-son and mother-daughter correlation coefficients. Nor is there any evidence for statistical interactions of sex with any of the factors studied.

The National Child Development Study seems well suited to resolving questions such as the above. The sample contains many more children than all the above longitudinal studies put together, and the fact that the measurements are generally less accurate, does not appreciably detract from this advantage. Furthermore, there seems to have been little attempt up till now, to examine the joint and partial effects of several factors, each of which separately has an effect on height.

Previous studies have adopted different sampling designs in order to overcome difficulties surrounding the analysis of the effects of parity and the number of children in the family. It has been found useful in the present study, to consider the two variables, parity and the number of younger siblings, separately so that the effect of parity can be studied after allowing for the number of younger siblings and vice versa. This then makes the effect of parity comparable at different ages, in particular at birth (when there are no younger siblings). It is found that after allowing for the number of younger siblings, the effect of parity on height at age seven is opposite to the effect of parity on birthweight (Butler and Alberman 1969), where later children are heavier. It is generally accepted that the intrauterine environment is most favourable for later children. It therefore seems that the postnatal environment, shared as it is with older children who are in a sense competing for similar resources, is relatively unfavourable to the younger child. When subsequent children appear the environment becomes more unfavourable.

The age of the mother has an effect on height which is small, but persists after allowance has been made for the other factors. It is not clear what the biological significance of this might be, particularly since maternal age does not seem to affect birthweight after allowance is made for similar factors (Butler and Alberman 1969). It may be that this effect represents residual social factors associated with the mother's age, for example illegitimacy.

From the analysis of birthweight and gestation it is clear that the "small for dates" baby tends to be shorter than average at 7 years, as other studies have shown. When length of gestation is analyzed separately, irrespective of birthweight and allowing for age, children born before 38 weeks are on average 1.1 cm shorter than those born between 38 and 42 weeks. If age is measured from conception however, then

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at a fixed age from birth the children with shorter gestations will be younger, there being an average difference of 4½ weeks between the lengths of gestation in the above two groups. This raises the question of whether the effect of gestation can be accounted for by measuring age from conception rather than from birth. A complete analysis of this problem is beyond the scope of the present paper, but it may be noted that the average growth in 4½ weeks at seven years is about 0.5 cm, which is just under half the average difference in height between these two gestation groups.

Smoking in pregnancy is related to height at seven, even after allowing for all the other factors. This evidence is new and adds further weight to those arguments in support of the damaging effects of cigarette smoking.

Each factor, apart from length of gestation, which separately has an effect on height, also shows a statistically significant although reduced effect, when allowance is made for all the other factors.

When all the factors are considered jointly, the effect on the child's height may be large. Thus a first born seven year old child from a Social Class 1 or 2 family with no younger siblings, a birthweight of 4000 gm, and with a mother at the 90^{th} percentile of height (170 cm) who did not smoke after the 4th month of pregnancy and was aged 25 or over at the birth of her child is on average 13.8 cm taller than a 4th or later born seven year old child from a Social Class 5 family with 2 or more younger siblings, a birthweight of 2500 gm and with a mother at the 10th percentile of height (155 cm) who smoked after the 4th month of pregnancy and was aged under 25 at the birth of her child.

SUMMARY AND ABSTRACT

The heights of the children in the National Child Development Study (all children born in England, Scotland and Wales during the week of 3rd—9th March, 1958) have been measured between seven and eight years of age. Information was also obtained on the Social Class of the child's father, the age and height of the child's mother, her smoking habits during pregnancy, the parity, birthweight and length of gestation of the child and the number of younger siblings. The associations of these variables with height have been analysed both singly and jointly, in all cases making allowance for the age and sex of the child.

Contrary to some previous studies the present data provide no evidence of statistical interactions between sex and any of these variables; thus

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for example, the height differences between social classes are the same for both boys and girls.

Social class 1 or 2 children are, on average, 3.3 cm taller than those from social class 5. When allowance is made for the other variables (including mother's height) this difference is reduced to 1.8 cm.

Instead of considering the total number of children in the family, the two variables, parity and the number of younger siblings have been used. After allowing for the other variables, first born children are, on average, 2.3 cm taller than fourth or later born children, and those children with no younger siblings are 1.1 cm taller than those with three or more (irrespective of the child's birth order).

Birthweight and length of gestation are both associated with height at seven years. The average gain in height for each kilogram of birthweight is 2.8 cm. Children born before the 38th week of gestation are on average 1.1 cm shorter than those born between 38 and 42 weeks. When all the other variables are allowed for, the gestation effect becomes non-significant; but the average gain in height for each kilogram of birthweight is only slightly reduced, being 2.1 cm.

The correlation coefficient between the height of the mother and the height of the child is 0.33 for boys and 0.32 for girls, with a standard error of 0.013 in both cases. The average gain in height for each cm of mother's height is 0.27 cm, after allowing for the other variables.

Children of mothers who were under 25 years old when the child was born, after allowing for the other variables are on average 0.6 cm smaller than the children of mothers aged 25 or over.

After allowing for the other variables, the children of mothers who smoked 10 or more cigarettes a day after the 4th month of pregnancy, are on average about 1.0 cm shorter at age seven than the children of mothers who did not smoke.

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