Social environment and height: England and Scotland 1987 and 1988

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Abstract

This study was designed to investigate the social characteristics associated with the height of primary schoolchildren aged from 5 to 11. Data were analysed for 8491 representative sample children measured in England and Scotland in 1987 and 1988 and 3203 inner city children measured in England in 1987. Height was negatively associated with social class but the association was not significant after allowing for biological variables. A negative gradient of height with size of sibship was evident in white children but was less so in Afro-Caribbean and Asian children. The individual associations of 11 different environmental characteristics were examined after allowing for biological factors and size of sibship. Consistent associations with height included a negative gradient of height with increasing latitude and an association of taller stature with increasing maternal age. A social class gradient in height is accounted for by associations with biological factors, particularly the parental heights; environmental attributes are weakly associated with height after allowing for biological factors.

Children's height is a sensitive indicator of their physical wellbeing, and has been recommended as a measure of their nutritional state.¹ Associations between height and environmental characteristics have been investigated as possible indications of adverse influences on growth. In such investigations a number of variables including the paternal social class²⁻⁷ and employment,⁵ the family size,^{4,5} the number of parents at home,⁸ and the presence of overcrowding⁸ have been used to characterise social conditions during childhood.² A gradient associating height with social class has been documented both in adults³ and children,⁴⁻⁷ but the existence of a gradient does not itself indicate a direct influence on growth. An association between height and a given social characteristic is difficult to interpret because of the number of confounding variables among the social characteristics of the child's environment and between social and biological factors. It is necessary to adjust for confounding variables with multiple regression analysis but this raises the question: what confounding variables should be allowed for in such analyses?

The National Study of Health and Growth is a surveillance study which was set up in 1971 to monitor the growth of primary schoolchildren in England and Scotland.⁹ In 1983 a second (inner city) sample was recruited.⁸ Reports from

this study have shown associations between height and a number of characteristics of the social environment including paternal social class and employment,^{5,8} type of school meals,¹⁰ presence of overcrowding in the home, and the educational attainment of the mother.⁸ The selection of variables for inclusion in these analyses has, however, been inconsistent.

We therefore undertook the present analyses to examine the problem of confounding variables in more detail. We aimed to define the variables that should be included in analyses and to re-examine the association between children's height and paternal social class for children living in England and Scotland in 1987 and 1988.

Subjects and methods

SUBJECTS

Two samples were recruited into the National Study of Health and Growth. The initial sample included children from schools in 22 employment exchange areas in England and 14 in Scotland, which were selected by stratified random sampling.⁹ The characteristics of children from this sample are similar to those of the general population,^{8,11} and the sample will be referred to as 'representative' in this paper.

The inner city (selective) sample was selected by identifying 10 electoral wards in England with high incidences of overcrowding, male unemployment, or shared household amenities. In addition five wards were selected each of which had a high proportion of families from Asian backgrounds, and five each of which had a high proportion of families from Afro-Caribbean backgrounds. The wards that were selected because of their ethnic composition are also inner city areas with characteristics of deprivation. For the present analysis, data measured in 1987 were analysed for the inner city sample and data measured in 1988 for the English representative sample together with that measured in 1987 and 1988 for the Scottish children. Data for the small number of non-white children in the representative sample were excluded from analysis as were data from children aged less than 5 or over 11 years on their last birthday.

METHODS

The methods used in the survey have been described previously.⁹ Children were measured at school by school nurses, 10% of measurements were checked by a full time fieldworker from the study team. Height was measured

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using a portable Holtain stadiometer to the last complete 0.1 cm.¹² The ethnic group of the child was classified according to the language spoken at home and by the fieldworker's subjective assessment of the child's ethnic group.⁸ The child's parent or guardian was asked to complete a self administered questionnaire containing questions relating to the child's health and the social background of the family. The questionnaire also requested information concerning the adult heights of the child's parents and the child's birth weight.

ANALYSIS

Parental heights and the child's birth weight are of greatest importance in explaining the variations in children's height; cases containing missing values on these continuous variables were therefore excluded from analysis. For categorical variables a 'not known' category was defined for each variable. Height standard deviation (SD) scores were used for the analysis of children's heights. The score was calculated for each child as the difference between the child's height and the mean height for English representative sample children of the same age and sex divided by the SD for that group. This method of expression standardises for age and sex and for the increasing variation in height with age. One SD score is roughly 5–7 cm between the ages of 5 and 11 years.

Categorical variables were classified as follows. The length of pregnancy was grouped into four categories: less than 38 weeks, 38 to 42 weeks, more than 42 weeks, or 'not known'. The number of children in the family was grouped into six categories: one, two, three, four children, five or more, or 'not known'. The age of the mother at the child's birth was categorised as: less than 20, 20 to 23, 24 to 27, 28 to 31, over 32, or 'not known'. The birth order of the child (the number of older siblings) was used as a proxy for maternal parity. In the inner city sample the ethnic group of the child was classified into seven categories: white, Afro-Caribbean, Urdu, Gujarati, Punjabi, other Asian, 'other' and 'not known'.

Paternal social class was defined by the Registrar General's classification, which for analysis was reduced to the following categories: non-manual, skilled manual, semiskilled and unskilled manual; a category for families headed

by a single mother; not applicable and not known. Maternal social class was defined by the mother's present or previous occupation and was classified into: non-manual, skilled manual, semiskilled and unskilled manual, full time housewife, other, or not known. Paternal employment was divided into: employed, unemployed less than 12 months, unemployed more than 12 months, unemployed (duration unknown), not applicable and not known. Maternal employment was divided into: employed, not employed, at home, not applicable and not known. The hours worked by the mother outside the home were categorised as: less than 15/week, 15 to 25, more than 25, no outside work, or not known. Maternal educational attainment was divided into: primary, secondary, commercial or technical, university, no school education, or not known. Mother's age at finishing full time education was divided into the following categories: less than 12 years, 12 to 16 years, 17 to 19 years, 20 to 23 years, 24 or more, not applicable or not known.

The receipt of benefits included unemployment benefit, income support, and family credits; it was classified as received, not received, or not known. The receipt of free school meals was classified into received, not received, not applicable and not known. The degree of overcrowding in the home was estimated by dividing the number of people in the accommodation by the number of rooms (excluding kitchen and bathroom). This index was categorised into five groups: less than 1 person per room, 1 to 1.24, 1.25 to 1.49, 1.50 or more, or not known. A categorical variable was also included for country of residence (England or Scotland).

The independent associations between explanatory variables and height SD scores were estimated by multiple linear regression analysis. To take into account the potential for mutual confounding of the variables, the analysis was undertaken in three stages. Firstly, the unadjusted association between paternal social class and the children's height was examined. Secondly, a model was constructed to include all the biological variables that were independently associated with height. This model included the parental heights, the child's birthweight, the reported length of pregnancy, the birth order and the child's ethnic group (for the inner city sample). The country of residence was also included in this model for the represen-

Table 1 Height SD score by paternal social class in the representative sample and the ethnic groups of the inner city sample. Values are expressed as unadjusted mean (SE) height SD score

Ethnic group	No of subjects	Paternal social class			Single mother	Not known
		I-III A Non-manual	IIIB Skilled manual	IV-V Semiskilled and unskilled manual		
Representative sample:						
England	5117	0.105 (0.023)	0.000 (0.024)	-0.024 (0.039)	0.016 (0.043)	-0.067 (0.050)
Scotland	3374	0.062 (0.030)	-0.048 (0.029)	-0.074 (0.042)	-0.103 (0.052)	-0.072 (0.075)
Inner city sample:						
White	1397	0.043 (0.078)	-0.236 (0.051)	-0.303 (0.059)	-0.167 (0.057)	-0.351 (0.070)
Afro-Caribbean	388	0.603 (0.166)	0.499 (0.118)	0.187 (0.171)	0.527 (0.082)	0.712 (0.112)
Urdu	112	-0.055 (0.244)	-0.359 (0.167)	-0.123 (0.208)	-0.685 (0.398)	-0.534 (0.167)
Gujarati	271	-0.510 (0.174)	-0.516 (0.104)	-0.749 (0.131)	0.454 (0.469)	-0.718 (0.131)
Punjabi	616	-0.027 (0.114)	-0.137 (0.075)	-0.067 (0.069)	-0.001 (0.189)	-0.271 (0.089)
Other Asian	120	-0.553 (0.258)	-0.086 (0.193)	-0.387 (0.213)	-0.457 (0.301)	-0.412 (0.225)
Other	299	-0.140 (0.155)	0.191 (0.141)	-0.138 (0.169)	0.553 (0.178)	-0.385 (0.130)

tative sample. The sibship size was also included in this model because of its strong association with children's height. The resulting model was used to adjust individually the associations of each of the remaining social characteristics with height SD score.

Finally all these social variables were included simultaneously and their independent effects assessed using a stepwise procedure with backward elimination of the least associated variable at each step. A conservative probability of 0.10 was used to retain variables in this model.¹³ In each analysis the height SD scores of the children were used as the dependent variable. Independent variables were entered as continuous variables except where the categorisation of the variable had previously been indicated.

Results

Data for the representative sample and for the inner city sample were analysed separately. Data from 11 267 representative sample children (mean height SD score -0.015) measured in England in 1988 or in Scotland in 1987 and 1988 were available for analysis. After excluding cases containing missing values on continuous variables 8491 cases (mean height SD score 0.009) were analysed. For the inner city sample measured in England in 1987, 6580 cases (mean height SD score -0.168) were available for analysis; after excluding cases containing missing values 3203 cases (mean height SD score -0.133) were analysed.

Among English representative sample children there was a significant gradient in height with paternal social class ($F=4.42$; df 4,5112, $p=0.001$) (table 1). Children living in Scotland were shorter than English children ($F=6.13$, df 1,8489, $p=0.013$). The association of height and paternal social class was also significant for

Scottish children ($F=3.21$, df 4,3369, $p=0.012$). For the inner city sample there was also a gradient of height by paternal social class, although this was not independent of ethnic group (table 1). White inner city children were shorter than white representative sample children allowing for differences in social class ($F=35.61$, df 1,9869, $p<0.001$).

Adjusting for biological variables (parental heights, length of pregnancy, birth weight, and ethnic group) eliminated the association between social class and height in England and Scotland. Additional analyses showed that adjusting for parental heights alone was sufficient to account for the social class gradient in height. Adjusting for parental heights alone also accounted for the difference in height between the representative sample and inner city white children in each social class category, but differences in height between the ethnic groups remained significant after adjusting for parental heights ($F=31.74$, df 6,11680, $p<0.001$).

Both the birth order and size of sibship were associated with children's heights. Height increased with increasing birth order (after adjusting for size of sibship) but the effect of size of sibship was quantitatively more important. In both England and Scotland there was a negative association between size of sibship and height SD score (table 2). In the inner city sample a trend towards decreasing height with increasing size of sibship was also seen for white children, but in the Asian and Afro-Caribbean children this gradient was diminished or absent. The first order interaction between ethnic group and size of sibship was significant ($F=8.09$, df 41,3161, $p<0.001$).

The individual associations of height SD scores with social attributes, adjusted for parental heights, birth weight, length of pregnancy, size of sibship, birth order, and country of residence (representative sample) or ethnic group

Table 2 Height by size of sibship. Values are expressed as unadjusted mean (SE) SD score

Size of sibship	English representative	Scottish representative	English inner city	Afro-Caribbean	Asian
1	0.260 (0.051)	0.117 (0.061)	0.180 (0.091)	0.526 (0.138)	-0.123 (0.213)
2	0.067 (0.020)	0.051 (0.025)	-0.121 (0.048)	0.619 (0.114)	-0.036 (0.078)
3	-0.014 (0.028)	-0.087 (0.033)	-0.311 (0.057)	0.468 (0.119)	-0.309 (0.063)
4	-0.082 (0.046)	-0.244 (0.055)	-0.316 (0.074)	0.511 (0.139)	-0.231 (0.074)
≥5	-0.007 (0.061)	-0.171 (0.086)	-0.522 (0.096)	0.438 (0.154)	-0.374 (0.058)

Table 3 Individual associations between height SD score and social variables each adjusted for parental heights, birth weight, length of pregnancy, size of sibship, birth order, and country of residence (representative sample) or ethnic group (inner city sample)

Independent variable	Representative sample			Inner city sample		
	F	df	p Value	F	df	p Value
Paternal social class	1.13	4	0.339	0.66	4	0.617
Paternal employment	1.32	4	0.260	4.62	5	<0.001
Maternal age	4.15	5	<0.001	4.92	5	<0.001
Maternal social class	0.56	4	0.690	4.56	4	0.002
Maternal employment	3.32	3	0.019	6.17	3	<0.001
Maternal hours of work	1.50	4	0.199	4.81	4	<0.001
Maternal education	1.13	5	0.342	2.06	5	0.068
Overcrowding	1.76	4	0.134	0.92	4	0.454
Benefits	1.22	2	0.295	6.89	2	0.001
School meals	1.38	3	0.247	9.40	3	<0.001
Longitude	0.31	1	0.579	26.78	1	<0.001
Latitude	16.16	1	<0.001	27.70	1	<0.001

(inner city sample) are shown in table 3. For the representative sample shorter stature was associated with younger maternal age at the child's birth and with the mother not being currently employed. The latitude of residence was also associated with height.

The use of the stepwise procedure resulted in the selection of the parental heights, the child's birth weight, length of pregnancy, size of sib-

Table 4 Model defined using stepwise procedure for representative sample. Values given are coefficient (SE) for continuous variables and mean difference (SE) from last mentioned category for categorical variables, each adjusted for every other variable

Independent variable	Coefficient (SE)	F ratio
Intercept	-17.697 (0.535)	
Maternal height (cm)	0.048 (0.001)	1072.9
Paternal height (cm)	0.041 (0.001)	991.9
Birth weight (kg)	0.332 (0.019)	308.5
Latitude (°N)	0.031 (0.007)	19.2
Length of pregnancy:		
<38 weeks	0.194 (0.041)	10.8
38-42 weeks	0.041 (0.031)	
>42 weeks	-0.310 (0.196)	
Not known	0	
Country of residence:		
England	0.069 (0.034)	4.2
Scotland	0	
Size of sibship:		
1	0.144 (0.055)	13.0
2	0.003 (0.047)	
3	-0.075 (0.048)	
4	-0.147 (0.054)	
≥5	-0.194 (0.064)	
Not known	0	
Maternal age:		
≤19	-0.133 (0.124)	4.9
20-23	-0.144 (0.119)	
24-27	-0.126 (0.118)	
28-31	-0.078 (0.118)	
≥32	-0.013 (0.119)	
Not known	0	
Maternal employment:		
Employed	0.011 (0.055)	3.5
Not employed	-0.183 (0.089)	
At home	-0.032 (0.056)	
Not known	0	

Residual mean square 0.71, df 8469.

Table 5 Model defined using the stepwise procedure for the inner city sample. Values given are coefficient (SE) for continuous variables and mean difference (SE) from last mentioned category for categorical variables, each adjusted for every other variable

Independent variable	Coefficient (SE)	F ratio
Intercept	-10.117 (1.006)	
Maternal height (cm)	0.039 (0.002)	256.9
Paternal height (cm)	0.031 (0.002)	216.4
Birth weight (kg)	0.360 (0.032)	124.7
Latitude (°N)	-0.044 (0.016)	7.6
Longitude (°W)	-0.049 (0.020)	5.7
Length of pregnancy:		
<38 weeks	0.127 (0.059)	4.6
38-42 weeks	-0.062 (0.042)	
>42 weeks	-0.152 (0.328)	
Not known	0	
Ethnic group, size of sibship, and interaction	42 levels not shown	4.3
Birth order:		
1	-0.026 (0.078)	2.1
2	-0.152 (0.078)	
3	-0.100 (0.084)	
4	-0.129 (0.097)	
5+	-0.194 (0.102)	
Not known	0	
Maternal age:		
≤19	-0.031 (0.119)	2.4
20-23	-0.006 (0.109)	
24-27	0.029 (0.109)	
28-31	0.104 (0.112)	
≥32	0.175 (0.113)	
Not known	0	
School meals:		
Not free	0.210 (0.066)	4.3
Free	0.077 (0.061)	
Other	0.139 (0.068)	
Not known	0	

Residual mean square 0.84, df 3140.

ship, latitude and country of residence, maternal age, and employment position as significant associations of height (table 4). For the inner city sample, after adjusting for biological factors, ethnic group and size of sibship, taller stature was associated with: father currently employed, mother currently employed, older age of the mother, non-manual occupation of the mother, and the mother working more than 25 hours/week outside the home. Shorter stature was associated with the receipt of benefits including free school meals and with increasing latitude or longitude of the study area (table 3). The use of the stepwise procedure resulted in the selection of the parental heights, the child's birth weight, the length of pregnancy, the birth order, size of sibship, ethnic group (interacting with size of sibship), maternal age, type of school meals, and latitude and longitude of residence as significant associations with height (table 5).

Discussion

These data show that the heights of primary schoolchildren vary according to country of residence, ethnic group, and paternal social class. The analysis was designed to identify environmental characteristics that were independently associated with height.

In the representative sample a large proportion of the explained variation in children's heights is accounted for in association with parental heights.^{4,5} For the inner city sample the associations of birth weight and parental heights accounted for a smaller proportion of the variation in children's heights.⁸ This may be partly accounted for by the greater variation in the child's social and ethnic background but it has also been shown that the validity of the parents' self reported heights is less among the inner city sample.¹⁴ After allowing for parental heights, birth weight, length of pregnancy, and country or ethnic group, the gradient in height with social class was not significant; these biological factors account for much of the social class variation in children's height.

The association between the heights of parents and children is well documented and is compatible with a genetic mechanism.¹⁵ The influence of a common family environment cannot be discounted,¹⁶ but the finding of a strong parent-child association in height that accounts for the social class gradient tends to argue against an immediate environmental cause of social class differences in height during childhood. There is evidence that selection of social class by height does occur,¹⁷ but social mobility also seems to have a quantitatively small effect in determining social class gradients in height.¹⁸

There does not seem to be a strong inter-generational association for birth weight,¹⁹ but environmental factors may have important influences on growth in the antenatal period and account for some of the variation in height at older ages.²⁰ Although there is an association between increasing birth order and increasing height,²¹ our findings show that this is less important than the negative association with size of sibship. Birth order was not selected as

having an independent association with height for the representative sample, and was only weakly associated with height when selected by the stepwise procedure for the inner city sample. The pattern of association between the number of children in the family and height varied between the different ethnic groups. In each of the samples of white children (English representative, English inner city, and Scottish) height diminished with increasing family size. Among Afro-Caribbean children and Asian children the gradient of height with size of sibship was reduced or absent.

The mechanism for the effect of family size on height is not well established. It has been suggested that economic factors are responsible,² smaller amounts of poorer quality food being available to children from larger families.²² In the National Study of Health and Growth a higher proportion of children in the ethnic minority groups come from larger families.⁸ The finding that the gradient of height with size of sibship is less in these groups suggests that the patterns of child care are also differently associated with family size in the ethnic groups. Simons (in a study of Sikhs living in London) found that although actual family size was not significantly greater than that of the white population, Sikhs preferred larger families including male children.²³ Thus one characteristic of larger families from the ethnic minorities that might distinguish them from white families is that they are planned.

After allowing for biological factors, ethnic group, and family size the association of other social characteristics of the children were of small magnitude. More were significant in the inner city sample than in the representative sample. The age of the mother at the time of the child's birth was significantly associated with height in each of the samples and was consistently selected by the stepwise procedure. There was a gradient of increasing height with increasing age of the mother at the time of the child's birth. This association was reported previously by the National Study of Health and Growth⁵ and has been described in other surveys.^{4 24} The recent trend towards increasing maternal age²⁵ may be one of the factors associated with the secular trend towards increasing height in Britain.²⁶ It is also relevant that there is a trend towards decreasing post-neonatal mortality with increasing maternal age, and this observation is also compatible with an effect of maternal age on child care.²⁷

Paternal unemployment is known to be associated with children's height,⁵ but in these analyses we found that this association was not significant in the representative sample after adjusting for parental heights, birth weight, length of pregnancy, size of sibship, birth order, and country of residence. The effect of maternal employment on children's development has been the subject of debate.^{28 29} Here, the employment position of the mother was associated with taller stature of primary school children. The receipt of free school meals was strongly associated with shorter stature for children in each sample but after adjustment this was significant only in the inner city sample.

In each of the samples, children's height diminished with increasing latitude of the study area, which is consistent with the gradient observed in the adult population.³⁰ In the inner city sample height kept a negative association with latitude after adjusting for confounding variables, but for the representative sample the direction of the gradient was reversed after this adjustment. The gradient in height with latitude in this sample is thus more than accounted for by the other confounding variables.

Size of sibship is the social characteristic showing the strongest association with height, although the nature of this association depends on the ethnic background. Other social characteristics were of only marginal importance. Among the variables examined, the age of the mother at the time of the child's birth and the latitude of residence were consistently associated with height across the two samples. The receipt of free school meals and non-employment of the mother were also associated with shorter stature. These analyses help to characterise the variables that should be included in adjustment for confounding, when attempting to characterise influences on growth during childhood; they also emphasise the greater importance of biological compared with social factors as influences on height for children living in England and Scotland.

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St Vitus, Sydenham, and the Bruegels

For over 400 years (13th to 17th centuries) a strange form of hysterical crowd behaviour occurred in Europe. This was the dancing mania, the original St Vitus' dance. Crowds of people would suddenly begin to dance in circles and continue to the point of exhaustion. Their stomachs would swell and some would fall to the ground as if in an epileptic seizure (R H R and M P Park, *Journal of the Royal Society of Medicine* 1990;83:512-5).

Two saints were named as protectors of these people, St John the Baptist and St Vitus, but later St John became associated with epilepsy and St Vitus with the dancing mania. Sufferers from the dancing affliction were prone to relapse on the saints' feast days (24th and 15th June).

Vitus is first mentioned in the 5th century. He was the son of a senator in Sicily and preached in southern Italy, was credited with expelling a demon from the son of the Roman Emperor Diocletian, was tortured, and eventually suffered martyrdom.

The *Epileptic Women of Molenbeek* is a pen and ink drawing in the Albertina in Vienna copied by the younger Bruegel from the work of his father. It depicts sufferers not from epilepsy but the dancing mania who are about to be cured by being thrown off a low bridge into the water near to St John's chapel. The cure apparently lasted a year.

Why Thomas Sydenham applied the name of St Vitus to acute chorea is not clear. He probably lived too late to have seen the severe form of dancing mania (chorea imaginativa of Paracelsus) but may have seen a minor form of the disorder which Paracelsus called chorea naturalis and borrowed the term 'St Vitus's dance' from that.

Treatment of Sydenham's chorea

While on the subject of St Vitus's dance, a report from Kuwait (Daoud *et al*, *Neurology* 1990;40:1140-1) suggests sodium valproate as a treatment for acute chorea. Thirteen of 15 children responded completely within a week. One 7 year old who responded had had chorea for two years and had previously failed to respond to haloperidol, chlorpromazine, phenobarbitone, and diazepam.

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