HEIGHT AND REPRODUCTIVE SUCCESS IN A COHORT OF BRITISH MEN

Daniel Nettle
The Open University, Milton Keynes, UK

Two recent studies have shown a relationship between male height and number of offspring in contemporary developed-world populations. One of them argues as a result that directional selection for male tallness is both positive and unconstrained. This paper uses data from a large and socially representative national cohort of men who were born in Britain in March 1958. Taller men were less likely to be childless than shorter ones. They did not have a greater mean number of children. If anything, the pattern was the reverse, since men from higher socioeconomic groups tended to be taller and also to have smaller families. However, clear evidence was found that men who were taller than average were more likely to find a long-term partner, and also more likely to have several different long-term partners. This confirms the finding that tall men are considered more attractive and suggests that, in a noncontracepting environment, they would have more children. There is also evidence of stabilizing selection, since extremely tall men had an excess of health problems and an increased likelihood of childlessness. The conclusion is that male tallness has been selected for in recent human evolution but has been constrained by developmental factors and stabilizing selection on the extremely tall.

KEY WORDS: **Height; Human evolution; Mate choice; Reproductive success**

Two recent studies have found that male tallness is associated with increased reproductive success in contemporary developed-world popula-

Received January 15, 2002; accepted March 7, 2002.

Address all correspondence to Daniel Nettle, Departments of Biological Sciences and Psychology, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK. E-mail: D.Nettle@open.ac.uk

Human Nature, Vol. 13, No. 4, pp. 473–491. 1045-6767/01/$1.00+.10

tions. The first, by Pawlowski and colleagues (2000), used medical records of men aged 25–60 in Wroclaw, Poland. The authors found that, for two subpopulations of the sample, tallness was a highly significant though weak predictor of the number of children a man had for his age. In the second study (Mueller and Mazur 2001), the sample consisted of a cohort of military academy graduates for whom extensive physical, health, and life course information had been gathered. Mueller and Mazur found that male height was associated with increased numbers of children. The mechanism by which this occurred was not increased fecundity of the tall men's wives, but rather a higher probability that the taller men would take a second or subsequent wife. Moreover, there was no relationship between height and socioeconomic status within the Mueller and Mazur sample, so the mechanism of selection on tall men was directly through their physical attractiveness to potential mates rather than indirectly via their socioeconomic achievements. Thus it seems that tall men enjoy increased fitness by their intrinsic ability to attract more mates.

Mueller and Mazur also examined the type of selection involved. Rather than there being a threshold of height above which no further advantage accrues by being taller, they suggest that fitness increases linearly with increasing height. They also find no evidence of stabilizing selection impacting negatively on the extremely tall. They thus conclude that selection for male tallness is unconstrained in the human population and will lead to the evolution of ever-increasing male height until some limit or constraint is reached.

These recent results stand in contrast to those of an older study (Vetta 1975), which used data from a large sample of Harvard alumni (Damon and Thomas 1967). Vetta's analysis suggested an inverse U-shaped relationship between male height and number of children, with a decline in offspring among extremely short and extremely tall men. Vetta's paper was silent on whether the peak of the U was at the mean height for the population, though it was evidently close to it, and did not go into any more detail about the health, marital, or socioeconomic histories of the men involved. Thus the mechanisms associating height and reproductive success, and possible confounding factors, could not be further scrutinized.

The present study investigates similar effects in the UK's National Child Development Study (NCDS). This is an ongoing longitudinal study of all the children born in the UK in one week in 1958. The cohort members are now 42, and a considerable amount of information about their physical development and social and reproductive lives is now available. These data enable questions to be asked about the relationship between height and reproductive success.

The questions to be pursued within this dataset are as follows. First, is there an increase in reproductive success with increasing tallness? The two recent studies found an effect by looking at populations of men who were quite homogenous in other ways. The NCDS, by design, covers the whole range of the UK population of a particular age set in an unbiased way, so if an effect is found, it will show that the reproductive advantage of tallness holds generally across the population.

Any increase in numbers of children for tall men may be confounded by the fact that men of higher socioeconomic status tend to be taller, but that in modern societies the higher socioeconomic groups choose to have smaller families. Because of this effect, over a modern population the number of children born to taller men may actually be less even if they are more successful at attracting partners. One way of countering this is to look at the number of long-term partners the men have. Mueller and Mazur (2001) found that tall men's reproductive advantage resided in their ability to attract second and third wives. This substantiates a solid psychological finding that taller men are rated more attractive than shorter ones (Feingold 1982; Gillis and Avis 1980; Hensley 1994; Hensley and Cooper 1987; Jackson and Ervin 1992). If taller men attract more mates, then we can infer that they are the beneficiaries of a psychological mechanism of attractiveness which in ancestral environments would have meant increased reproductive success, even if today other factors intervene.

The two recent studies cited above did not find the number of children confounded by socioeconomic status group differences. However, they restricted the domain of comparison to relatively homogenous subpopulations—just military officers in Mueller and Mazur (2001), just rural or just urban men in Pawlowski et al. (2000). Mueller and Mazur argue that, in modern societies, different socioeconomic strata constitute essentially separate marriage markets. Success within each stratum may be correlated with number of children, but since each stratum has different norms, comparing across the strata will find no correlation between number of children and factors such as tallness. The key factors segregating society into different strata are education and social class. The present dataset can be divided into separate strata to investigate the extent to which this picture is correct. Data on both occupational class and educational level are available for all the men.

The second question to be investigated here concerns the interaction between height and socioeconomic status (SES). Being tall is robustly associated with high socioeconomic status (Peck and Lundberg 1995; Silventoinen et al. 1999). There are two possible, non–mutually exclusive directions of causality for this effect. On the one hand better maternal nutrition and better health care within the higher SES groups could lead to men growing taller. On the other hand tall men, through the strong association of height and attractiveness, could be advantaged in professional and social competition, thereby tending to rise to more rewarded professions. If they enjoy a reproductive advantage, this could be directly due to their attractiveness, or indirectly due to the socioeconomic status they have been able to achieve. The current dataset allows these effects to be teased apart to some extent. Occupational class is recorded for the men's fathers as well as the men themselves at 42 years of age, so we can examine the extent to which parental background predicts tallness, and the extent to which tallness predicts change in social class for the men themselves.

The third area suitable for investigation using this dataset is the existence of stabilizing selection. Mueller and Mazur (2001) claim, contra Vetta (1975), that there is no evidence of stabilizing selection on the basis of their sample. However, the range of their sample is seriously restricted in this regard. The military academy's admissions criteria specified minimum and maximum heights (62–78 inches). This range is not a drastic restriction (more than 99% of British adult males born in 1958 fall within it). However, some men at the top of the height continuum will have been debarred on this basis. More damningly in methodological terms, only those of excellent physical health and condition will have been able to enter. This will necessarily exclude any men suffering health problems that may be height-related. Good health may be related to attractiveness, and thus to reproductive success. The finding from the Mueller and Mazur study that there are no negative effects of extreme tallness is thrown into question by the fact that any man suffering such effects would quite likely not make it into the academy in the first place. The Pawlowski et al. (2000) dataset as presented provided no evidence of stabilizing effects, but the authors did not test for any. Nor it is it clear how completely the clients of the medical center represent the range of Polish men.

Stabilizing effects on tallness could be of two sorts. *Developmental constraints* are limitations on the adult height that can be achieved by the processes of maturation and growth. Size at birth is a strong predictor of adult height. Increasing in utero growth makes metabolic demands on the mother. Moreover, delivery through the birth canal constrains the circumference of the baby's head at birth. This circumference is highly correlated with overall size. Obstetric complications were a major source of morbidity and mortality in both mothers and children in the past and continue to be so in the developing world. In some African countries, even today, a woman's lifetime risk of death related to childbirth can be as high as 1 in 20 (Chamberlain 2001). Given that increasing baby size beyond an optimum level increases obstetric problems, developmental constraints will check the evolution of tallness. Developmental constraints can of course be overcome by natural selection acting to change the proportion of growth occurring before and after birth, but this will have knock-on effects on other aspects of life history and health. Thus, in the short evolutionary term, developmental constraints could be a major stabilizing factor on tallness.

The other type of stabilizing factor is direct negative selection on extremely tall men. If these men suffer either increased health problems or decreased attractiveness, then the evolution of tallness would be checked even if moderately tall men had an evolutionary advantage. There is evidence to suggest that both factors could be significant. While short men have poorer health overall (Silventoinen et al. 1999), there are increased risks with increasing height for musculo-skeletal problems (Heliovaara et al. 1991) and for certain cancers (Michaud et al. 2001; Shors et al. 2001). As for attractiveness, Hensley (1994) finds that whereas young men who are taller than average have more dates than shorter ones, the extremely tall have slightly fewer. The significance of such effects in terms of reproductive success has not been demonstrated.

METHODS

The National Child Development Study is an ongoing medical and sociological study of all the children born in the United Kingdom in the week of March 3–9,1958. Information was gathered close to the time of birth using questionnaires and also medical and psychological assessments (Butler and Bonham 1963). There have been six attempts to contact the cohort over the intervening years, and these repeated "sweeps" provide a rich source of longitudinal information on their social and medical trajectories (Ferri 1993; Fogelman 1983). The most recent contact with the cohort was in 2000, at a cohort age of 42 years (Bynner et al. 2001); the one before that was in 1991, at a cohort age of 33 years (Ferri 1993). It is principally those two "sweeps," in conjunction with the original perinatal survey, which provided the data used here.

The initial size of the NCDS cohort was 17,414 boys and girls. Many individuals have been lost to follow-up over the years. The number successfully contacted in 1991 was 11,407, and in 2000 it was 11,419. Some of those lost to follow-up will have died, but it is not possible from the information available at this time to say who they were. Thus, hypotheses about the relationship of stature to early mortality cannot be tested here. There were 5,471 men among those with valid height values from 2000, though not all had complete records for all of the other variables used in the analysis. It is not possible to determine whether loss to follow-up operated randomly with respect to social class, stature, or reproductive success, and so results reported here concern those men still in the study, without further consideration of the problem of missing data.

Height

Stature was recorded many times in the different sweeps of the study. The measure used here, HEIGHT, represents the subject's self-reported height in 2000, in inches. Subjects were given the choice of responding in metric or imperial units, and, reflecting their generation, overwhelmingly chose imperial. Thus the imperial values are used here. The minimum height was 60 inches. The highest values were isolated scores of 91 and 92 inches, though it is not clear if these represent data entry errors, since they are a full ten inches greater than the next tallest value. The tallest value with more than one occurrence was 79 inches. The mean was 69.81 inches with a standard deviation of 2.69 inches.

HEIGHT correlates well with measures of height taken during earlier sweeps, by direct measurement as well as self-report, with the coefficient increasing as the members grew towards their adult statures. The correlations are as follows: HEIGHT with measured height at 7 years, $r_s = 0.66$, $n = 4496$, $p < 0.001$; HEIGHT with measured height at 11 years, $r_s = 0.71$, $n = 4332$, $p < 0.001$; HEIGHT with measured height at 16 years, $r_s = 0.75$, $n = 3905$, $p < 0.001$; HEIGHT with self-reported height at 23 years, $r_s = 0.93$, $n = 4528$, $p < 0.001$. Though height is often held up as a paradigm of a normally distributed variable, it here demonstrated significant skewness and kurtosis, perhaps related to the rounding of values to the nearest inch. For the purposes of analysis, then, men were divided into deciles and quartiles on the basis of HEIGHT, and an analysis of variance approach comparing the height classes was used in lieu of correlation and regression.

Reproductive Success

Cohort members were asked about the relationships and children in their lives in 1991. In 2000, they were asked to report any changes in these areas since 1991. Thus, combining information from the two sweeps provides information about the whole life span to the age of 42. The male reproductive career is not complete at 42, but it is sufficiently far advanced for significant patterns to have emerged.

Two measures were produced by amalgamating several variables from the 1991 and 2000 sweep datasets. The first of these is the number of children fathered, CHILDREN. The structure of the questionnaire allows for the possibility that children were produced by several partners, and out of wedlock. Since the data are based on self-report, no account can be given of children fathered covertly or indeed children believed to be fathered who were not in fact so. Previous studies suggest that the rates of these events will not be negligible, but there is no way of detecting them within this dataset. It is reasonable to infer that they are sufficiently infrequent to make effects discernible without taking account of them.

There were 4,586 valid values for the CHILDREN variable. The mean number of children fathered was 1.81, with a standard deviation of 1.33 and a maximum of 12. In all, 987 of the men, or 17.5%, were childless.

In both 1991 and 2001, cohort members were asked to list the major relationships that they had had, including dates of beginning and ending, and whether they were married. "Major" in this context meant that the couple had cohabited. These records were put together to give the total number of major relationships up to age 42. This variable, known as RELATIONSHIPS, could be calculated for 4,649 men. The modal value was 1, accounting for 64.7% of the men. Three hundred and seventy men (8.0%) reported no relationship. The maximum value was 8, the mean 1.3, and the standard deviation 0.81. The RELATIONSHIPS variable takes no account of more fleeting sexual contacts which might take place before or outside of marriage. However, it does allow us to identify both those who never had a committed partnership and those who formed more than usual.

Socioeconomic Status and Educational Group

As discussed above, a possible confounding factor is differences in socioeconomic group among the men. The conventional I–V divisions of occupational class (with I the highest SES and V the lowest) were available for both the men themselves, based on their occupation at age 42, and their fathers', based on occupation in 1958. The distribution of men into classes is shown in Table 1. In conjunction with their fathers' classes, this information could be used to calculate an index of class trajectory, which is simply the men's class minus their fathers'. This takes a value of 0 if the class in the same, 1 if they have moved up one, −1 if they have moved down one, and so on. The mean social class trajectory was 0.44 (s.d. = 1.07) rather than zero, reflecting the secular trend towards middle-class occupations.

A classification based on educational level was also prepared. Information from within the dataset could be used to divide the men into those who had left full-time schooling at or before age 16, those who had left at

Table 1. The Breakdown of the Men into Educational Groups and Occupational Classes

Age left full-time education	*N*
16 or before	3,540
17 or 18	986
Post-18	967
Occupational class in 2000	***N***
I	375
II	2,009
III	2,100
IV	426
V	128

17 or 18, and those who had continued into higher or further education. The distribution of the men into these categories of EDUCATION is given in Table 1.

Health Variables

The men's birthweight for gestational age was recorded in 1958, as were various aspects of their births, including duration of the first and second stages of labor, whether the birth was induced, unusual deliveries, and any evidence of fetal distress.

Cohort members were asked in 2000 whether they had any long-standing illnesses or disabilities, and if so whether their capacity to work was impaired. These answers were used here to create a summary variable DISABILITY, with a value of 1 if a work-impairing health problem was reported, 0 otherwise.

RESULTS

Height and Number of Children

Neither height decile nor height quartile was associated with significant differences in number of children (Deciles: $F_{(8,4461)} = 1.28$, $p = 0.25$; Quartiles: $F_{(3,4466)} = 1.64$, $p = 0.18$). Although post-hoc tests revealed no significant differences between any of the deciles or quartiles, the trend was for the taller men to actually have fewer children (Figure 1). This is largely an effect of different educational or social norms. Men in the more educated groups tended to have fewer children ($F_{(2,4471)} = 7.61$, $p < 0.01$; Figure 2). They also tended to be taller ($F_{(2,5260)} = 38.09$, $p < 0.01$; Figure 3). As argued above, there could be a correlation between tallness and number of children within different social groups even if class differences in family size meant there was no relationship at the population level. To investigate this, the sample was split up, first by education and then by occupational class, and the analysis of variance of children by height was run separately for each subgroup of men (Table 2). Of the eight ANOVAs produced (3 for education, 5 for class), only one is significant (class III), and the differences in that case are not in the direction predicted. Thus it seems that there is no evidence even within more homogenous social groupings for a relationship between tallness and number of children.

As noted above, the number of children people have today is strongly a product of social norms around contraception and may not reflect past selective pressures. Tall men might still be better at attract potential child-rearing partners, even if that no longer correlates with having more

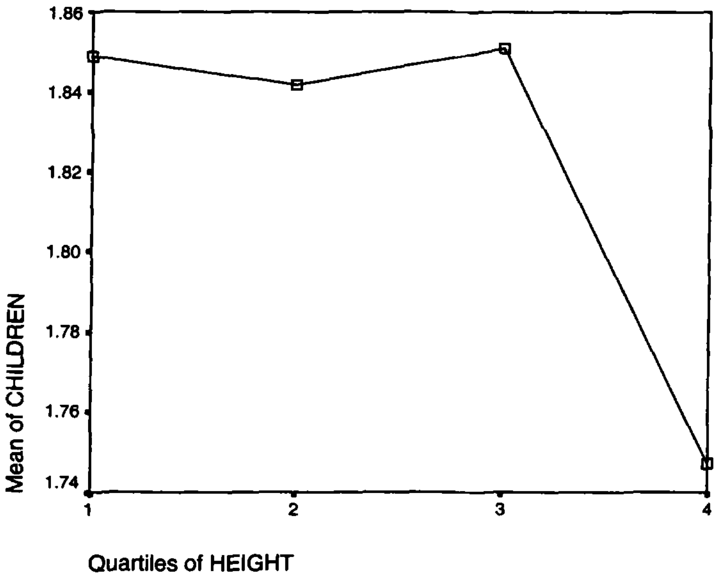

Figure 1. Mean number of children by quartile of HEIGHT (4 = tallest), whole cohort.

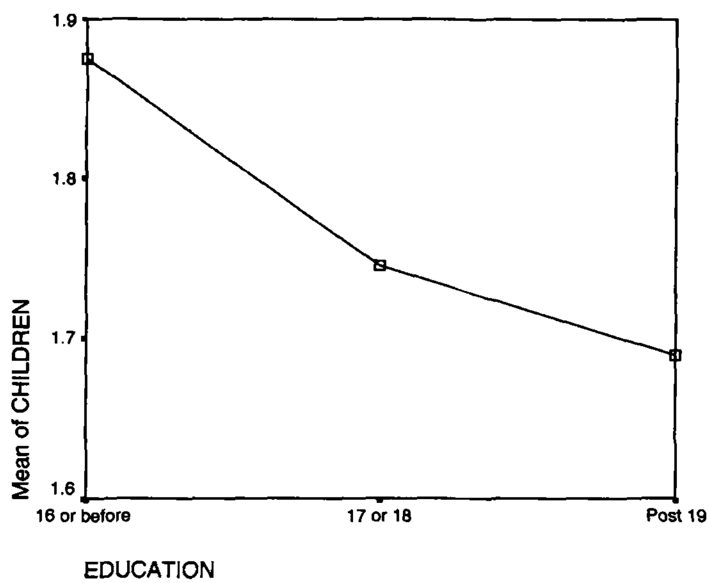

Figure 2. Mean number of children by educational group, whole cohort.

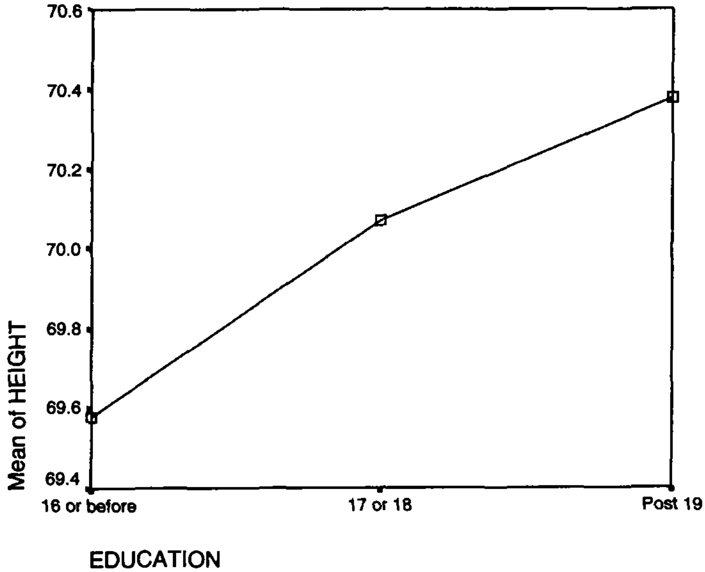

Figure 3. Mean height by educational group.

Table 2. ANOVA of Number of Children by HEIGHT Quartile with the Cohort Broken Down into Subgroups by Education and Class

Group	F-*ratio*	*df*	p
Education			
16 or before	2.06	3, 2788	0.10
17 or 18	1.29	3, 808	0.28
19 plus	0.78	3,765	0.51
Class			
I	1.11	3, 304	0.35
II	0.24	3, 1646	0.87
III	2.68	3, 1720	0.05
IV	0.89	3, 326	0.45
V	2.08	3, 92	0.11

offspring in today's environment. Men in the bottom decile of HEIGHT were significantly more likely to be childless than those in the other nine deciles (Table 3; $\chi^2 = 6.31$, df = 1, $p = 0.01$). This effect was restricted to the extreme end of the distribution; there was no significant excess of childlessness in the bottom quartile of HEIGHT compared with the other three quartiles ($\chi^2 = 0.81$, df = 1, $p = 0.37$).

Table 3. Expected and Observed Numbers of Childless Men in the Bottom and Other Deciles of HEIGHT

	Expected	*Observed*
Bottom decile	93.5	114
Other deciles	854.5	834

Tallness and Relationships

Unlike number of children, the number of serious relationships reported (RELATIONSHIPS) was unrelated to educational group ($F_{(2,4533)} = 0.04$, $p = 0.97$) or social class ($F_{(4,4248)} = 1.29$, $p = 0.09$). Thus an association between stature and relationships could be pursued without fear of confounding from educational or socioeconomic differences.

Quartiles of HEIGHT are associated with number of relationships ($F_{(3,4536)} = 2.99$, $p = 0.03$). As height increases, men have an increasing number of different long-term partners on average (Figure 4). Men in the lowest quartile of height are more likely than expected to report no relationship, and less likely than expected to report three or more major relationships (Table 4; $\chi^2 = 12.59$, df = 3, $p = 0.03$). The increase in mean number of relationships in taller men is not solely due to a smaller proportion of taller men having

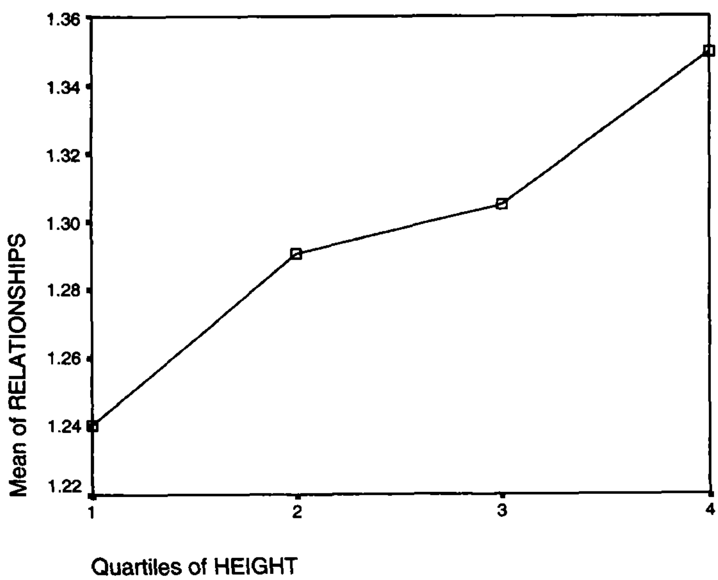

Figure 4. Mean number of relationships by quartile of HEIGHT (4 = tallest).

Table 4. Numbers of Relationships Reported by Men in the Bottom HEIGHT Quartile

	Expected	*Observed*
None	61	76
One	515.5	507
Two	157	169
Three or more	60.5	42

Table 5. Numbers of Relationships Reported by Men in the Top HEIGHT Quartile

	Expected	*Observed*
None or one	858.2	831
Two or more	323.8	351

no relationship at all. There are also significantly more men in the tallest quartile with two, three, or more relationships than would be expected by chance (Table 5: $\chi^2 = 4.26$, df = 1, $p = 0.04$).

The Relationship between Tallness and Socioeconomic Group

Men in the higher social classes were taller than the others ($F_{(4,4914)} = 76.37$, $p <$ 001), with a difference of around one inch in the means for the class V and class I men. This difference could arise in two ways; men born into more privileged social classes could become taller due to better health and nutrition, or taller men could be more successful occupationally and move up in class. The data suggest the former, since a man's father's social class is actually a slightly better predictor of his adult height than his own social class (father's social class and HEIGHT: $F_{(4,4943)} = 100.30$, $p < 0.001$; the respective η^2 values are 0.09 for own social class and HEIGHT, and 0.11 for father's social class and HEIGHT). There is no relationship between a man's height and his class trajectory (the difference between his own social class and his father's: $F_{(8,4459)} = 1.34$, $p = 0.22$).

Thus the evidence strongly suggests that in the association of tallness and social class, social class is the determinant of tallness rather than the other way around. Moreover, the greater number of relationships tall men have seem to be due to their direct attractiveness rather than the fact that they are more economically successful or upwardly mobile than other men.

Developmental Constraints and Stabilizing Selection

A possible developmental constraint on the evolution of stature comes from the fact that to produce taller men, women have to give birth to larger babies, with all the health risks that may bring. In this cohort, adult height among the men is indeed associated with birthweight for gestational age ($F_{(5,4491)} = 72.56, p < 0.001$). In order to produce taller sons, women are having to give birth to much larger babies (Figure 5). There must be upper limits on the size of infants they can safely carry and give birth to. There is some evidence that giving birth to males who would become tall had an impact on the delivery. For men in the top HEIGHT quartile, there was more likely to be a long (over 60 minutes) second stage of labor ($\chi^2 = 4.12$, df = 1, $p = 0.04$), and the birth tended to be more likely to be induced ($\chi^2 = 3.41$, df = 1, result is approaching significance at $p = 0.07$). However, there was no evidence that men in the top height quartile (or decile) had a greater likelihood of non-standard delivery (forceps, caesarean), or experienced fetal distress (for top quartile: $\chi^2 = 0.23$, df =1, $p = 0.63$ for delivery type; $\chi^2 = 0.64$, df = 1, $p = 0.42$ for fetal distress).

Direct stabilizing selection can also be investigated. When the HEIGHT distribution is broken down into deciles, the maximal number of relationships is exhibited not by the top decile but by the eighth decile (Figure 6), with reduced numbers in the ninth and tenth. This suggests a U-shaped effect, with increased attractiveness experienced by men of above-average height, but a subsequent reduction of ability to attract mates at the very end of the distribution. This possibility is reinforced by the fact that the top

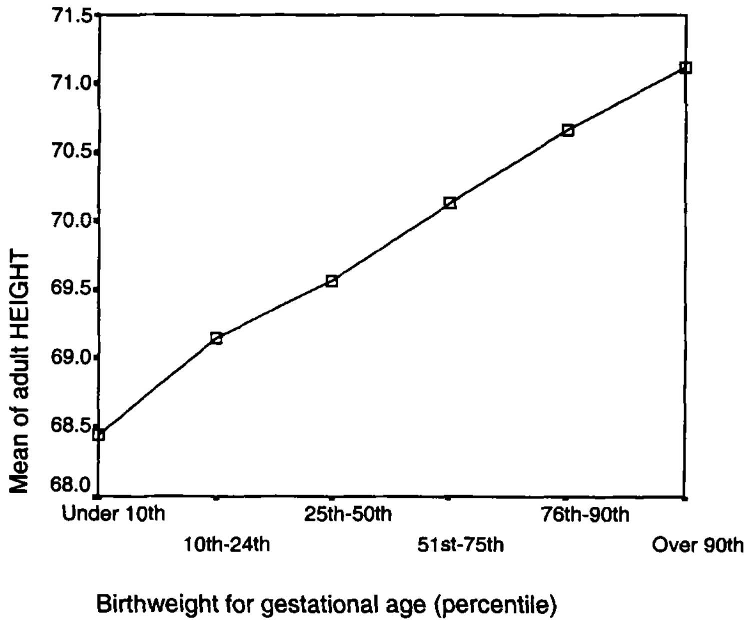

Figure 5. Adult height related to percentiles of birthweight for gestational age.

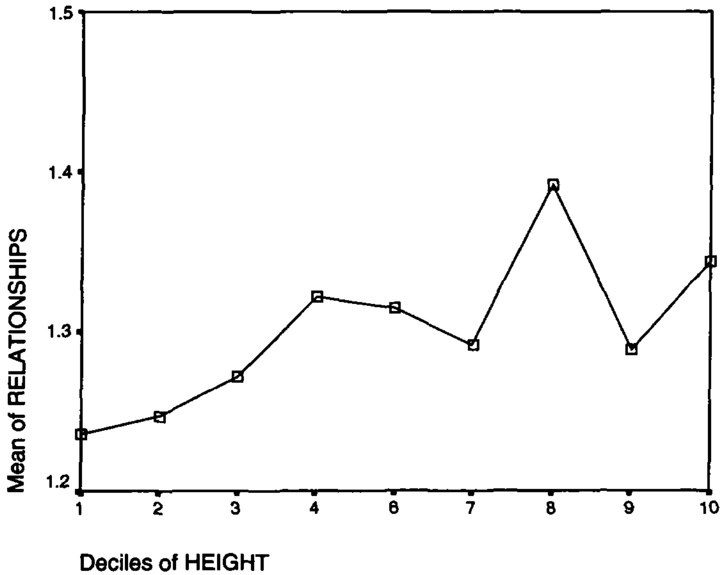

Figure 6. Mean RELATIONSHIPS by decile of HEIGHT (10 = tallest).

decile of men were slightly more likely than others to be childless, a result which approached significance ($\chi^2 = 3.32$, df =1, $p = 0.07$).

Men in the top decile of HEIGHT were more likely than others to have a work-impairing, long-standing illness ($\chi^2 = 5.31$, df = 3, $p = 0.02$), as did the men in the lowest decile ($\chi^2 = 7.42$, df = 3, $p = 0.006$). This suggests a U-shaped relationship between health problems and stature, with more problems among the very tallest and shortest men. The excess of childlessness in the top decile of HEIGHT may well have been modulated by a reduction in the ability to attract partners by men who had health problems. In the whole cohort, men with a work-impairing, long-standing illness were more likely than expected to be childless ($\chi^2 = 8.55$, df = 1, $p = 0.003$), or to report no relationship ($\chi^2 = 29.89$, df = 3, $p < 0.001$).

DISCUSSION

The main findings from this cohort were as follows. Taller men were significantly less likely to be childless than shorter men. However, unlike the findings of Pawlowski et al. (2000) and Mueller and Mazur (2001), taller men did not have a greater mean number of children than shorter men. A possible reason for this, and a major limitation of the study, was that the men were only 42 years old. Men may still have additional children for several more years, and since tall men were more likely to have changed to a second or third partner, who will often be younger, it is likely that many of them are still carrying on their reproductive careers. The Pawlowski et al. (2000) sample were of a wide range of ages, whilst the Mueller and Mazur (2001) cohort were at least two decades older than the current cohort.

Furthermore, the relationship between number of children and tallness in this study was affected by the association between height and socioeconomic status to a greater extent than for the other studies, which used more socially restricted samples. In modern populations, the higher classes choose smaller family sizes, as well as tending to be taller. Analysis of the reasons for this pattern is beyond the scope of this paper, but they are generally assumed to involve the evocation by aspects of the social context of mechanisms which have evolved to optimize the trade-off between offspring number and offspring quality (Borgerhoff Mulder 2000). In preindustrial societies, the relationship between social status and family size is generally the reverse of that found here (Borgerhoff Mulder 1987), with number of wives a good predictor of number of children. Thus in a noncontracepting context, taller men would have more children.

The results show that taller men were more successful at attracting long-term mates. They were less likely to have had no long-term partner, and more likely to have had more than one, than their shorter peers. This did not appear to be a result of greater socioeconomic success, since there was no relationship in this cohort between tallness and upward class trajectory. The association between social class and stature appeared to stem from differences in social class at birth affecting final height, rather than the tall stature facilitating upward mobility. This agrees with Silventoinen et al.'s (2000) conclusions from a twin study, and also with Hensley and Cooper's (1987) sceptical review of the evidence that tall stature predicts occupational success. It is in disagreement, though, with a couple of other studies that have suggested tallness could function as cause as well as consequence of socioeconomic differences (Cernerud 1995; Peck 1992).

Tall men's greater number of partners seems to be a direct consequence of their stature increasing their ability to attract a partner. This confirms the now-abundant finding that women find taller men attractive (Feingold 1982; Gillis and Avis 1980; Hensley 1994; Jackson and Ervin 1992; Shepperd and Strathman 1989).

A significant limitation of the present dataset is that the only relationships recorded were long-term ones that included cohabitation. These are likely to form only one component of a man's final reproductive success. Short-term matings also occur, either illicitly during other relationships, or during bachelor periods. Survey evidence from British men of the same age as those studied here gives a median lifetime number of partners of around 7, and a significant rate of extra-pair mating (Johnson et al. 2001). This means that short-term liaisons outnumber the long-term ones recorded in the NCDS several-fold. This is not as damaging for the present findings as might be imagined, for two reasons. First, such short-term matings relatively rarely have either the intent or the result of producing children. Second, the men who have more short-term matings are generally those who are seen as more attractive—in short, who have more long-term partners too (Pérusse 1994). Thus, the effect of short-term mating is likely to be to accentuate the pattern found here rather than to reverse it.

Mueller and Mazur (2001) suggest, from their military academy cohort, that selection for male tallness is unconstrained in the positive direction. If true, this would raise a considerable evolutionary puzzle. Unconstrained directional selection "uses up" heritable variation on the selected trait, since soon only those carrying the full set of maximally tall alleles survive (Fisher 1930). Thus one would expect heritable variation in tallness to disappear, and the heritability of stature to drop to zero. This is obviously not the case, as there is strongly heritable variation for stature left in the population (Chatterjee et al. 1999). The most likely reason for this is some form of stabilizing selection. Positive selection on taller-than-average men, coupled with stabilizing, negative selection on extremely tall men, would allow polymorphism in genes associated with tallness to persist, and thus heritability to remain high.

The present results partly concur with Vetta (1975) in that they find direct evidence of stabilizing selection. Although men in the tallest quartile of the population had the highest number of relationships, those in the tallest decile had an increased incidence of childlessness. They were also more likely to have a long-standing, impairing illness. Height has long been recognized as a predictor of health outcomes, though most usually in terms of the poorer health of short individuals (Barker et al. 1990; Silventoinen et al. 1999). Evidence for a U-shaped relationship, with poorer health among the extremely tall, has been found before (Heliovaara et al. 1991), though more usually among women than men (Silventoinen et al. 1999). Extreme height not only puts strain on the musculo-skeletal system (Heliovaara et al. 1991) but, associated as it is with growth hormone activity and tissue proliferation, appears to increase the risk of certain cancers (Michaud et al. 2001; Shors et al. 2001). Since long-standing illness itself predicts the ability to find a mate, there is evidently negative selection on being extremely tall. The optimum height for a man, from the present data, appears to lie about 80% of the way along the distribution, or 6 feet tall. This is a very similar conclusion to Hensley's (1994), based on attractiveness experiments amongst women.

There is also evidence that to suggest that producing an extremely tall son has a negative impact on the mother. The birthweights for gestational age of taller men were greater than those for shorter men. Though there was no clear evidence of increased obstetric complications in the birth of the taller men, the second stage of labor was longer and the birth tended to be more likely to be induced. Since obstetric complications are a major source of morbidity and mortality of both child and mother in all pre-industrial populations (Chamberlain 2001), it is reasonable to infer that the difficulties of giving birth to a large baby are a major constraint on the evolution of human stature.

The current results are important for several reasons. Generalizations about human mate preferences have tended to be based on hypothetical attractiveness scenarios (Hensley 1994) or questionnaires (Buss 1989), or ideal mate-seeking behaviors such as "lonely hearts" advertisements (Kenrick and Keefe 1992). It has less often been demonstrated that the traits preferred by one sex or the other in such situations are actually associated with reproductive success differentials in the real world. Such a demonstration is important if one intends to suggest an adaptive explanation for the evolution of a trait, or the preference for it. It is now clear that male tallness is robustly associated with advantages in finding mates in contemporary populations. The demonstration of stabilizing selection is also important, since it provides a mechanism for the maintenance of heritable variation in a population for a trait which is evidently not neutral. Similar effects may well be applicable to some of the other traits which are associated with heritable variation between individuals in the modern human population.

The National Child Development Study is carried out by the researchers of the Centre for Longitudinal Studies, Institute of Education, London. The data are housed at the Data Archive of the University of Essex, from where they were obtained under license for the present study. I am grateful to Paul Preece for his assistance with data processing, and to Benjamin Campbell and two anonymous referees for invaluable advice which has, I hope, improved the quality of this paper.

Daniel Nettle is lecturer in biological psychology at the Open University. With a first degree in psychology and a Ph.D. in biological anthropology, his work has been concerned with the application of evolutionary models to such topics as language (e.g., *Linguistic Diversity*, Oxford University Press, 1999) and individual differences (*Strong Imagination*, Oxford University Press, 2001).

REFERENCES

Barker, D., C. Osmond, and J. Golding
1990 Height and Mortality in the Counties of England and Wales. *Annals of Human Biology* 17:1–6.

Borgerhoff Mulder, M.
1987 On Cultural and Reproductive Success: Kipsigis Evidence. *American Anthropologist* 89:617–634.
2000 Optimizing Offspring: The Quantity-Quality Tradeoff in Agropastoral Kipsigis. *Evolution and Human Behaviour* 21:391–410.
Buss, D.
1989 Sex Differences in Human Mate Preferences. *Behavioral and Brain Sciences* 12:1–49.
Butler, N., and D. Bonham
1963 *Perinatal Mortality.* Edinburgh: E&S Livingstone.
Bynner, J., N. Butler, E. Ferri, P. Shepherd, and K. Smith
2001 *The Design and Conduct of the 1999–2000 Surveys of the National Child Development Study and the 1970 British Cohort Study.* London: Institute of Education, Centre for Longitudinal Studies.
Cernerud, L.
1995 Height and Social Mobility. *Scandinavian Journal of Social Medicine* 23: 28–31.
Chamberlain, G.
2001 Maternal Mortality. In *Turnbull's Obstetrics*, G. Chamberlain and P. Steer, eds. Pp. 741–752. London: Churchill Livingstone.
Chatterjee, S., N. Das, and P. Chatterjee
1999 The Estimation of the Heritability of Anthropometric Measures. *Applied Human Sciences* 18:1–7.
Damon, A., and R. B. Thomas
1967 Fertility and Physique: Height, Weight and Ponderal Index. *Human Biology* 39:5–13.
Feingold, A.
1982 Do Taller Men Have Prettier Girlfriends? *Psychological Reports* 50:810.
Ferri, E.
1993 *Life at 33: The Fifth Follow-up of the National Child Development Study.* London: National Children's Bureau, City University, Economic and Social Research Council.
Fisher, R.
1930 *The Genetical Theory of Natural Selection.* Oxford: Clarendon Press.
Fogelman, K.
1983 *Growing Up in Great Britain: Collected Papers from the National Child Development Study.* London: Macmillan.
Gillis, J. S., and W. E. Avis
1980 The Male-Taller Norm in Mate Selection. *Personality and Social Psychology Bulletin* 6:396–401.
Heliovaara, M., M. Makela, and P. Knekt
1991 Determinants of Sciatica and Low-back Pain. *Spine* 16:608–614.
Hensley, W. E.
1994 Height as a Basis for Interpersonal Attraction. *Adolescence* 29:469–474.
Hensley, W. E., and R. Cooper
1987 Height and Occupational Success: A Review and Critique. *Psychological Reports* 60:843–849.

Jackson, L. A., and K. S. Ervin
1992 Height Stereotypes of Women and Men—The Liabilities of Shortness for Both Sexes. *Journal of Social Psychology* 132:433–445.
Johnson, A., C. Mercer, B. Erens, A. Copas, S. McManus, K. Wellings, K. Fenton, C. Korovessis, W. Macdowall, K. Nanchahal, S. Purdon, and H. Field
2001 Sexual Behaviour in Britain: Partnerships, Practices, and HIV Risk Behaviours. *Lancet* 358:1835–1842.
Kenrick, D. T., and R. C. Keefe
1992 Age Preferences in Mates Reflect Sex Differences in Human Reproductive Strategies. *Behavioral and Brain Sciences* 15:75–133.
Michaud, D. S., E. Giovannuci, W. C. Willett, G. A. Colditz, M. J. Stampfer, and C. S. Fuchs
2001 Physical Activity, Obesity, Height and the Risk of Pancreatic Cancer. *Journal of the American Medical Association* 286:921–929.
Mueller, U., and A. Mazur
2001 Evidence of Unconstrained Directional Selection for Male Tallness. *Behavioral Ecology and Sociobiology* 50:302–311.
Pawlowski, B., R. I. M. Dunbar, and A. Lipowicz
2000 Tall Men Have More Reproductive Success. *Nature* 403:156.
Peck, M. N.
1992 Childhood Environment, Intergenerational Mobility and Adult Health: Evidence from Swedish Data. *Journal of Epidemiology and Community Health* 46: 71–74.
Peck, M. N., and O. Lundberg
1995 Short Stature as an Effect of Economic and Social Conditions in Childhood. *Social Science & Medicine* 41:733–738.
Pérusse, D.
1994 Mate Choice in Modern Societies: Testing Evolutionary Hypotheses with Behavioral Data. *Human Nature* 5:255–278.
Shepperd, J. A., and A. J. Strathman
1989 Attractiveness and Height: The Role of Stature in Dating Preference, Frequency of Dating, and Perceptions of Attractiveness. *Personality and Social Psychology Bulletin* 15:617–627.
Shors, A. R., C. Solomon, A. McTiernan, and E. White
2001 Melanoma Risk in Relation to Height, Weight and Exercise (United States). *Cancer Causes and Control* 12:599–606.
Silventoinen, K., J. Kaprio, and E. Lahelma
2000 Genetic and Environmental Contributions to the Association between Body Height and Educational Attainment. *Behavior Genetics* 30:477–485.
Silventoinen, K., E. Lahelma, and O. Rahkonen
1999 Social Background, Adult Body-height and Health. *International Journal of Epidemiology* 28:911–918.
Vetta, A.
1975 Fertility, Physique and Intensity of Selection. *Human Biology* 47:283–293.