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Original Research Article

Is Human Mating for Height Associated with Fertility? Results from a British National Cohort Study

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Objectives: Very few studies have investigated whether spousal similarity for height is related to fertility. This study examined the relationship between mating for height and fertility after correction for spousal age, social class, education, and region.

Methods: The data used were collected as part of the British National Child Development Study and 6,535 husband–wife pairs for whom data were available on measured height, spousal age, education, social class, region, and the number of children were studied.

Results: Fertility varied between the regions with the highest fertility in Scotland. Fertility tended to increase from more to less educated and from higher to lower social classes in both sexes. These relationships remained significant after correction for mean age. A negative association between husband's height in relation to fertility was noted as well as the negative and the quadratic term for wife's height. Both the linear as well as the quadratic effects of parental height difference were significantly related to fertility, but after removing the effects of mean age, age difference and mean height these effects disappeared. Analysis of region, mean age, social class, education, height, and differences in age, social class, education, and height together revealed that 32.4% of variation in fertility was explained but only mean age, mean social class and mean height and difference in social class remained significant.

Conclusions: The results did not provide any evidence that differential fertility was associated with spousal height difference after taking into account age, social class, education and region. Am. J. Hum. Biol. 27:553–563, 2015.

INTRODUCTION

Assortative mating is defined as a pattern of a positive (implying a tendency when phenotypically like mate with like) or negative (also called disassortative, where opposites mate) nonrandom mating between males and females, and has several important genetic and evolutionary consequences. Positive assortment increases homozygosity within loci, promotes the frequency of genotypes giving rise to extreme phenotypes, and increases population variance as well as parent–child and sib–sib correlations (Buss, 1985; Crow and Felsenstein, 1968; Falconer, 1981; Lynch and Walsh, 1998; Thiessen and Gregg, 1980). Furthermore, assortative mating is hypothesized to reduce the production of less fit phenotypically intermediate offspring (Jiang et al., 2013).

Positive assortative mating in humans has been reported for a large number of characteristics and in general, the association between partners is strongest for age, political orientation, social attitudes, and religion, and moderate for intelligence, education, physical attractiveness, height, weight, and personality traits (Price and Vandenberg, 1980; Watson et al., 2004; Zietsch et al., 2011). The relationship between stature and reproductive success analyzed separately for men and women is well documented in the literature but very few studies have examined the relationship between assortative mating for anthropometric characters and differential fertility. The initial studies were undertaken by Clark and Spuhler in the 1950s and 1960s. Using data collected in Ann Arbor, Michigan, Clark and Spuhler (1959), Spuhler (1962), and Spuhler (1968) reported on the extent of assortative mating for 43 anthropometric measurements. Of these 14 showed no significant assortative mating while for the remaining 29 measurements Spuhler constructed an index of similarity which measured the ratio of the husband's measurement to the sum of the husband's and wife's measurements.

As many couples in the Ann Arbor sample had not completed their reproductive period, Spuhler computed a fertility index which was the square-root transformation of months of exposure to pregnancy plotted against the number of live-born children. This index showed a strong, approximately linear, association between exposure and fertility. Using this index a fertility score was generated of the difference between the observed and expected fertility of each couple. The fertility score was normally distributed with a mean of 0.0003 and standard deviation of 1.06. The correlations between the 29 anthropometric similarity indices and fertility scores revealed that only one variable, minimum wrist circumference (+0.175) was significant. However, Spuhler only tested for the linear association whereas his similarity index would be expected to show a polynomial relationship with fertility assuming some underlying relationship between spousal likeness and number of live-born offspring.

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A relationship between educational similarity and differential fertility has also been reported. Garrison et al. (1968) in a USA study showed that positively assortative marriages for educational attainment resulted in the production of more children than negatively assortative marriages mostly because a larger percentage of negatively assortative marriages for education were childless. Mascie-Taylor (1986) using a British National cohort sample examined the relationship between educational homogamy and fertility and found that couples who had the same number of years of schooling had more children, on average, than couples with dissimilar years of schooling, before and after correcting, for spousal age. Mascie-Taylor (1986) also found a strong association between fertility and social class with families from lower social classes (classes IV and V) having more children, on average, than those from higher classes (I and II) before and after correcting for spousal age.

Mascie-Taylor and Boldsen (1988) using the same British national cohort went on to examine the relationship between spousal likeness in stature and the number of live-born children. After correcting for mean parental age, social class of the husband and regional differences in fertility, they reported that increasing spousal similarity for height associated with increasing numbers of live-born children as well as decreasing probability of having an abnormal pregnancy outcome referring to still-birth, perinatal death, congenital abnormalities, recognizable spontaneous abortions, and babies medically classified as light. However, Mascie-Taylor and Boldsen (1988) did not take into account spousal similarity in social class (only using the husband's class), parental age or the left truncated nature of the data. Instead of using the simple difference in stature between husband and wife, they calculated the difference between spouses using the standard normal deviate.

Another example of a study of the relationship between spousal height difference and some aspect of reproductive success has been presented by Stulp et al. (2011). Using data from the Millennium Cohort Study (UK), they analyzed the effect of parental height difference on the risk of emergency Caesarean section. Stulp et al. (2011) found that with increasing parental height difference, the risk of emergency Caesarean section increased, but the effect of parental height difference was restricted to women of average height and tall women whereas there was no effect in short women.

As has been pointed out by Bereczkei and Csanaky (1996) the primary relationships between husband and wife that determine the stability and success of marriage can be considered universal human traits. Regardless of the economic level and cultural structure of a society, it is of interest to study whether biologically prescribed mate preferences may produce more successful marriages and this marital success enhances fitness parameters measured by offspring count. In line with this statement, the present article uses the British national birth cohort (NCDS) and tests whether spousal stature difference associates with the number of live-born children, after taking into account regional variation in fertility as well as the association between spouses in age, social class, and education.

We predict that there will be positive assortative mating for height with tall men to be married more frequently with tall women and short men to be paired to short women more often than at random. If positive assortative mating contributes to marital stability as well as to the enhancement of the number of surviving children (Mascie-Taylor, 1988; Thiessen and Gregg, 1980), we also hypothesize that increasing spousal similarity in stature will be associated with an increasing number of live-born children. Furthermore, after correction for spousal similarity in age, social class, and educational level, assortative mating with respect to height will be weakly related to the number of offspring.

MATERIALS AND METHODS

The data were collected as part of the National Child Development Study (NCDS), the longitudinal survey of all children born in England, Wales and Scotland in the week 3–9th March 1958. The number of children initially studied in March 1958 was about 14,000. Children who entered the country after 1958 but who were born in this week have also been included and so the total sample size was 18,555 children. The children and their families were periodically restudied in 1965, 1969, and 1974. Thereafter, the index child was followed up into adulthood, and there were restudies in 1991, 2000, 2004, 2008, and 2013 (at ages of 33, 42, 46, 50, and 55, respectively). This article focuses on the 6,535 husband–wife pairs (parents who were still married 16 years after the birth of the index child) in 1974 for whom data on measured height (anthropometric data when fathers of the cohort members in 1958 were on average 30 years of age [30.4 ± 6.06, range 16–78] and mothers about 28 years of age [27.6 ± 5.40, range 16–47]) and fertility data as well as information about the region of the country the partners were living in, their level of education, and social class. The study was limited to couples who have had at least one child, hence the fertility data were left truncated. The overall pattern of attrition in the 1958 cohort study was similar to that in other British birth cohorts (Wadsworth et al., 2003, Plewis et al., 2004, Power and Elliott, 2006; Atherton et al., 2008) and due to common causes (refusal, moving, or death). Although the 1958 cohort showed attrition over time it remained largely representative of the total surviving cohort in terms of childhood and adulthood characteristics (e.g., there was a 2% higher percentage of husbands in social classes I and II in the husband–wife pairs analyzed compared with excluded husbands but very little difference in social classes III and IV and a deficit of 2% in social class V).

The number of live-born offspring per family was used as the fertility measure and was collected in 1974, a date which would be close to the end of the reproductive span for most mothers as their average age would then have been 44 years (only 1.7% of women were between 32 and 34 years of age, 23.4% between 35 and 39 and the remained over 40 years of age). Educational attainment was grouped into four categories of University, "A" level, "O" level and No qualifications. Social class was defined by the Registrar General's 5 point occupational scale, where I refers to professional, II to intermediate (mainly managerial), III skilled worker, IV semiskilled worker, and V unskilled. Due to smaller numbers, social classes I and II were combined. Wives with small children are often full-time housewives and have no formal social class, so the mother's father's social class was used as a proxy for the women's social class. In the analyses, the mean

TABLE 1. Comparison between models

Distribution	Log Likelihood	Akaike Information Criterion
Normal	−12639.74	25283.49
Normal, Positive	−11420.66	22845.31
Log-Normal	−11321.79	22647.57
Poisson, Positive	−11818.78	23639.56
Negative Binomial	−11815.97	23635.93

spousal educational level and mean spousal social class were used as well as the differences in spousal educational level and social class.

The mean spousal educational level was calculated (e.g., husband with "O" level and wife with University education, mean = 2). Likewise the four social classes were also scored 1–4 (social classes I + II, III, IV, and V, respectively) and the mean was determined. The differences in educational level and social class (husband–wife) were also calculated. For both education and social class negative values are indicative of higher educational level and social class of the husband (e.g., husband from social class III and wife from social class V, difference = −2). In addition, the mean spousal age and height were determined as well as the differences in age and height (husband–wife).

The variables used for this study were the number of live born children together with region (with Scotland the reference region), means and differences in spousal educational level, social class, age, and height.

All analyses were performed using R version 3.1.0 "Spring Dance."

RESULTS

Modelling the data

As the cohort study was based on children born in a specific week of the year only couples with at least one child were included and the distribution was restricted to strictly positive integer values (left truncation). Five models were tested to see which provided the best fit to the number of children per couple:

1. A normal distribution without constraint (Normal).
2. A normal distribution with the constraint of a null (zero) probability for negative counts (Normal, Positive).
3. A Log-Normal distribution which assumes strictly positive counts (Log-Normal).
4. A zero-truncated Poisson distribution, assuming null (zero) probability for values <1 (Poisson, Positive).
5. A zero-truncated negative binomial distribution, assuming null (zero) probability for values <1 (Negative Binomial).

Table 1 shows that the simple normal distribution without constraint gave a poor fit with an AIC much larger than the other 4 models. The Log Likelihoods as well as the AICs for the other four models were much closer, but the Log-Normal model gave the lowest Log Likelihood and the AIC was very similar for Log-Normal, Poisson, Positive, and Negative Binomial. When the distributions were superimposed on the histogram (Fig. 1) the observed data showed a much better fit to the Log-Normal model than the other models. So the Log-Normal model was used in the subsequent analyses although the number of

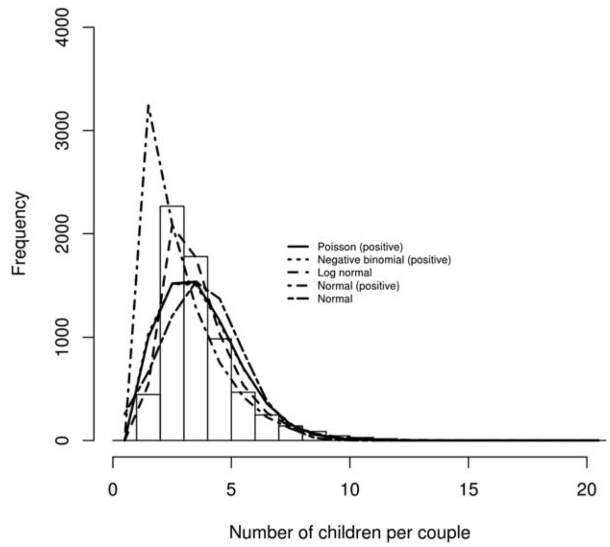

Fig. 1. Number of children per couple with models superimposed.

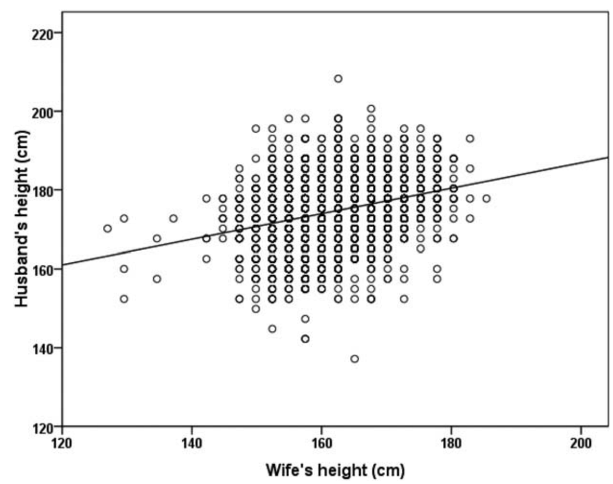

Fig. 2. Association between husband's and wife's height (cm) ($r = 0.28$).

live-births to each couple is not continuous but rather a discrete count variable.

Fertility by husband's and wife's height

The mean (geometric) fertility was 2.8 with a standard deviation of 1.6. The mean heights of husbands and wives were 174.7 cm (SD = 7.5) and 162.2 cm (SD = 6.5), respectively. There was a highly significant positive assortative mating for height ($r = 0.28$, $P < 0.001$) between spouses (Fig. 2).

The results showed a negative association between husband's height and fertility without a significant quadratic effect [intercept = 6.1590 (±2.2540), B for the linear term = −0.0520 (±0.0260), $F = 74.65$, $P < 0.001$, B for the quadratic term = 0.0001 (±0.00007), $F = 3.02$, $P = 0.082$] (Fig. 3). Wife's height appeared to modify the logarithm of the number of children and the linear as well as the

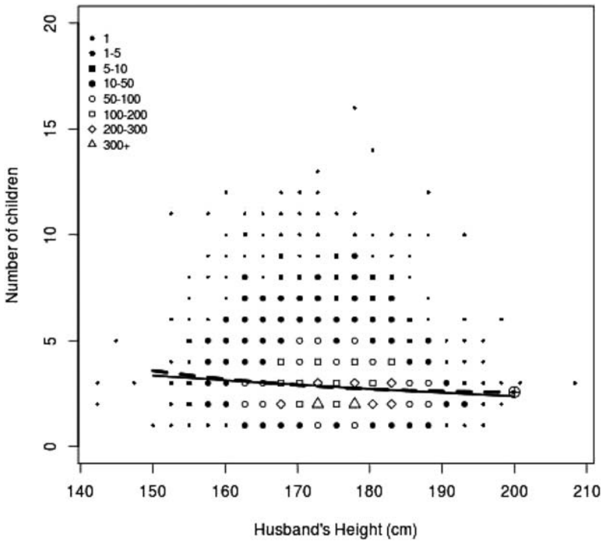

Fig. 3. The effect of husband's height on the number of children.

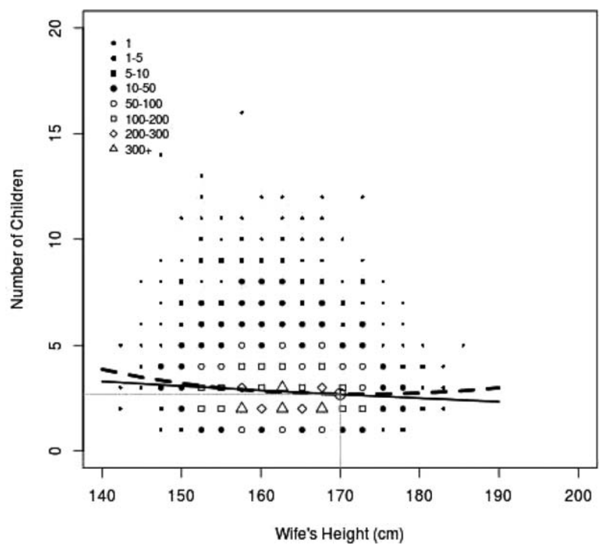

Fig. 4. The effect of wife's height on the number of children.

quadratic terms were highly significant [B for the linear term = -0.1191 (± 0.0315), $F = 54.64$, $P < 0.001$, B for the quadratic term = 0.0003 (± 0.00009), $F = 12.68$, $P < 0.001$] (Fig. 4). The relationship between wife's height and fertility remained significant before and after correcting for mean spousal age, whereas the association between husband's height and number of offspring disappeared after correcting for mean spousal age. There was no interaction between husband's and wife's height (Table 2).

The mean difference in height between spouses was 12.5 cm (SD = 8.4). It appeared that both the linear as well as the quadratic effects of the difference in height between spouses were significantly related to fertility with the lowest number of children among couples where husbands were taller than their wives about 15 cm. The linear trend was slightly negative ($B = -0.0056$, $F = 0.93$, $P = 0.047$), whereas the quadratic term was positive and more significant than the linear term ($B = 0.0002$, $F = 1.65$, $P = 0.008$). As Figure 5 shows, the impact of the quadratic term is mainly seen towards the ends of the distribution whereby taller wives (relative to husbands) and taller husbands (relative to wives) were slightly more fertile.

TABLE 2. Regression of fertility in relation to husband's and wife's height

	df	Mean square	F	p
Husband's height Husband's height^2	1 1	17.44 0.71	74.65 3.02	<0.001 ns
Wife's height Wife's height^2	1 1	12.78 2.97	54.64 12.68	<0.001 <0.001
Husband's height* Wife's height	1	0.53	2.28	ns
Residuals	6517	0.23		

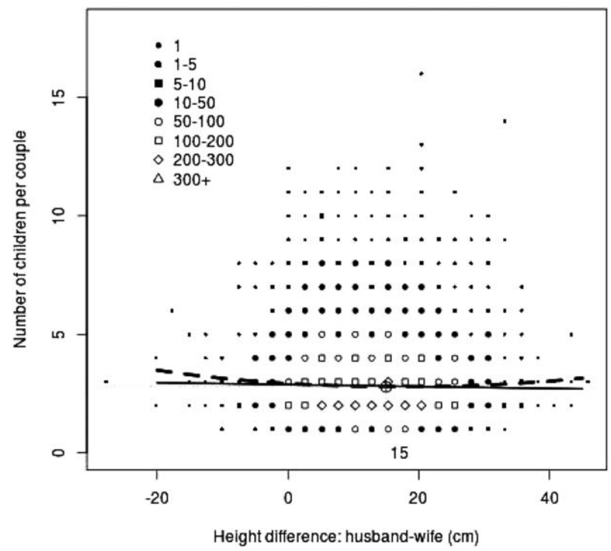

Fig. 5. The effect of parental height difference on the number of children.

Fertility by parental age, region, educational level, and social class separately

There was a highly significant positive correlation between husband's age and fertility (+0.18, $P < 0.001$) as well as between fertility and wife's age (+0.19, $P < 0.001$). Log normal regression analyses were undertaken separately for region, educational level and social class. The analyses revealed that there was significant variation in fertility between the nine standard regions (Table 3) with the highest fertility in Scotland and lowest in the East and South East as well as in Yorkshire and Humberside regions. There was also significant variation in fertility by educational level and social class (Tables 4 and 5). In both husbands and wives there was little variation in fertility between the educated groups compared with noneducated (marginal totals) and noneducated husbands and wives had the highest fertility on average. There was also a tendency for fertility to increase from higher to lower social classes in both husbands and wives (marginal totals) and the fertility was highest where both husband and wife were in social class V. The significant differences between regions, social classes, and educational level remained highly significant after taking into account mean spousal age.

Finally, a model using nine variables: region, means of spousal height, age, social class and educational level, and differences in spousal height, age, social class difference and educational difference was undertaken to see how much of the variation in fertility was explained. The results are summarized in Table 6. A negative coefficient indicates a lower fertility than the reference category, while a positive coefficient indicates higher fertility than the reference.

There were still marked regional differences with all regions having a lower fertility, on average, than Scotland. Only the South West and North West were not significantly lower. As mean height increased, fertility declined, while the opposite trend was found with mean age. Lower social classes were associated with higher fertility but education level was not significant. The differences in height, age, and educational level between spouses was not significantly related to fertility but there remained a highly significant social class difference effect with husbands from lower social classes who married wives of higher social classes having higher fertility (Fig. 6). Overall 32.4% of fertility was predicted in the full model primarily due to mean age (16.9%), mean social class (14.8%), mean height (7.7%), and parental difference in social class (5%).

TABLE 3. Fertility by region of the country the partners lived

Region	Number of children		
	n	Geometric Mean	95% CI
North	512	2.9	1.1–8.1
Yorkshire + Humberside	436	2.7	1.0–7.1
East Midlands	437	2.8	1.1–7.2
East + South East	2067	2.7	1.1–6.5
South West	469	2.8	1.2–7.0
West Midlands	652	2.8	1.0–7.4
North West	799	3.0	1.1–8.0
Wales	365	2.8	1.0–8.0
Scotland	782	3.1	1.2–8.2
Total	6519	2.8	1.1–7.3

DISCUSSION

This article evolved out of the finding of Mascie-Taylor and Boldsen (1988) that increasing assortative mating for height was associated with greater number of live-born children. Mascie-Taylor and Boldsen based their conclusions on the analysis of the British NCDS which examined all children born in 1 week of March 1958. The children and their families were restudied at ages 7, 11, and 16 and later in adulthood. The fertility of the couple was obtained in 1974 when most women would have been reaching the end of their fertile period. Mascie-Taylor and Boldsen took into account the age, social class and regional differences. The analyses that Mascie-Taylor and Boldsen undertook treated fertility as a continuous character which did not reflect the left truncation of the data (as all couples had to have at least 1 child to be in the cohort study). In this article, five different models were examined (Normal; Normal, Positive; Log-Normal; Poisson, Positive; Negative Binomial) and it was found that a log-normal distribution fitted the data best of all (based on Likelihood ratio and AIC). Therefore, all analyses were undertaken using the log-normal distribution.

Before we discuss our findings, some data as well as study caveat need to be expressed. First, our analyses were limited to couples who have had at least one child.

TABLE 4. Fertility (geometric mean) by partners' educational level

Husband	Wife														
	University			"A" level			"O" level			None			Total		
	n	Mean	95% CI	*n*	Mean	95% CI	*n*	Mean	95% CI	*n*	Mean	95% CI	*n*	Mean	95% CI
University	201	2.8	1.4–5.6	176	2.6	1.2–5.6	62	2.6	1.2–5.3	64	2.6	1.1–6.2	503	2.7	1.3–5.6
"A" level	98	2.4	1.1–5.5	342	2.5	1.1–5.7	224	2.4	1.1–5.2	229	2.6	1.1–6.5	893	2.5	1.1–5.8
"O" level	23	3.1	1.5–6.4	197	2.6	1.2–5.5	825	2.7	1.2–6.1	174	2.9	1.1–7.8	1219	2.7	1.2–6.2
None	65	2.8	1.2–6.9	397	2.7	1.1–6.7	828	2.8	1.1–7.1	2614	3.1	1.1–8.8	3904	3.0	1.1–8.2
Total	387	2.7	1.3–5.8	1112	2.6	1.1–6.0	1939	2.7	1.1–6.4	3081	3.0	1.1–8.5	6519	2.8	1.1–7.3

TABLE 5. Fertility (geometric mean) by partners' social class

Husband	Wife														
	I + II			III			IV			V			Total		
	n	Mean	95% CI	*n*	Mean	95% CI	*n*	Mean	95% CI	*n*	Mean	95% CI	*n*	Mean	95% CI
I + II	535	2.7	1.2–5.9	569	2.5	1.1–5.8	91	2.8	1.0–7.7	35	2.5	1.0–6.1	1230	2.6	1.1–6.0
III	549	2.7	1.1–6.5	2200	2.7	1.1–6.7	615	2.9	1.0–8.0	589	3.1	1.1–8.5	3953	2.8	1.1–7.1
IV	86	3.2	1.2–8.3	373	3.0	1.1–8.1	192	3.2	1.2–8.7	130	3.4	1.2–9.6	781	3.1	1.2–8.5
V	45	3.3	1.1–9.8	249	3.4	1.3–9.1	104	3.2	1.0–10.3	157	3.6	1.3–9.7	555	3.4	1.2–9.6
Total	1215	2.7	1.2–6.5	3391	2.7	1.1–6.9	1002	3.0	1.0–8.3	911	3.2	1.1–8.8	6519	2.8	1.1–7.3

TABLE 6. Regression analyses of fertility (log normal model) in relation to assortative mating for height, age, education and social class

	Coefficient	Multiplication factor[a]	95% CI	*P*	Effect size
Scotland (Reference)	1.526	1	3.21–6.83	<0.001	
North	−0.056	0.95	0.90–0.99	0.03	
Yorkshire & Humberside	−0.106	0.90	0.85–0.95	<0.001	
East Midlands	−0.076	0.93	0.88–0.98	0.007	
East & South East	−0.102	0.90	0.87–0.94	<0.001	
South West	−0.050	0.95	0.90–1.00	ns	
West Midlands	−0.089	0.91	0.87–0.96	<0.001	
North West	−0.033	0.97	0.92–1.01	ns	
Wales	−0.070	0.93	0.88–0.99	0.019	
Height mean	−0.007	0.99	0.99–1.00	<0.001	0.077
Age mean	0.015	1.11	1.01–1.02	<0.001	0.169
Social class mean	0.105	1.01	1.08–1.12	<0.001	0.148
Educational level mean	0.011	0.99	1.00–1.03	ns	
Height difference	0.001	1.02	0.99–1.00	ns	
Height difference*2	0.000	1.00	1.00–1.00	ns	
Age difference	−0.001	1.01		ns	
Social class difference	0.024			<0.001	0.050
Educational level difference	0.006			ns	

[a]The multiplication factor is the natural log value comparing with the reference (Scotland = 1), so for example North $e^{-0.056} = 0.95$.

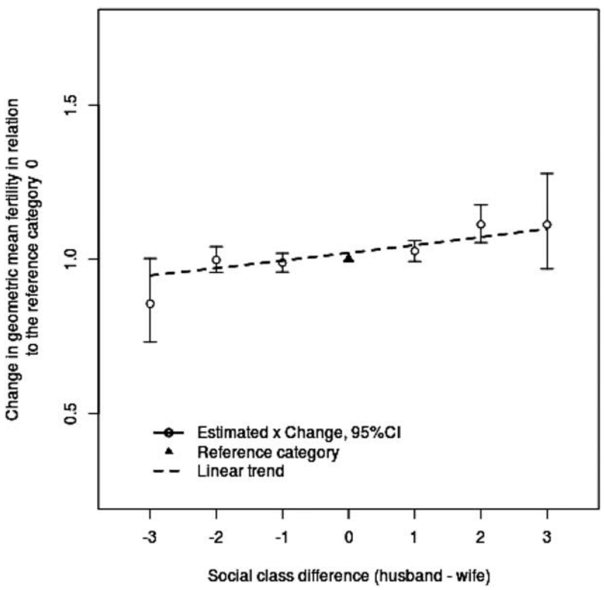

Fig. 6. Relationship between fertility and spousal difference in social class.

As has been suggested by Barthold et al. (2012), Fieder and Huber (2007) and Nettle and Pollet (2008) there is a difference between childless and single child couples in terms of accounting for lifetime reproductive success differentials in economically developed countries. For example, a study looking at partner preference in the association between lifetime reproductive success and income in contemporary Europeans showed that for individuals with at least one child, lifetime reproductive success was negatively associated with income for both sexes, whereas the probability of remaining childless increased with income for women, but it decreased with income for men (Barthold et al., 2012). Fieder and Huber (2007) and Nettle and Pollet (2008) found that, for men, the exclusion of childless individuals caused the relationship between lifetime reproductive success and income to change from positive to flat.

Second, in this study we examined the couples that have remained together for 16 years after the birth of the index child. Positive assortative mating in terms of age, region of origin, ethnicity, religion, education, social background, and relationship quality as well as relationship stability over time are linked (Frimmel et al., 2009; Gonzaga et al., 2007; Gruber-Baldini and Warner Schaie, 1986; Simpson, 1987) with more similar couples having more stable relationships. It is also well known that some physical characteristics such as height contributes to marriage formation and stability. In line with those studies as well as findings on height preferences in mate selection (Belot and Fidrmuc, 2010; Belot and Francesconi, 2006; Gills and Avis, 1980; Fink et al., 2007; Mascie-Taylor and Boldsen, 1988; Oreffice and Quintana-Domeque, 2010; Silventoinen et al., 2003; Stulp et al., 2013b, 2013c; Susanne and Lepage, 1988; Vaillant and Harrant, 2008), one might expect that the couples that were very similar in height had more unstable relationships and dropped out of the study. However, we examined the correlation in height between the 6,535 husband-wife pairs (0.28) and the correlation for the remaining 6,453 husband–wife pairs for whom there was information in 1958 (but not in 1974) and it was slightly lower at $r = 0.24$.

Simple models with region, educational level, social class, parental age, and height analyzed separately showed significant variation in fertility. The highest fertility has been noted in Scotland and lowest in East and South East as well as in Yorkshire and Humberside. Regional differentiation in the number of children in the UK has been confirmed by other researchers (Bayliss and Sly, 2009; Chamberlain and Smallwood, 2004; Whiting, 2010).

This study presented a widely known phenomenon of fertility differences by social class with a tendency for fertility to increase from higher to lower social classes in both husbands and wives. High social status has often been found to be associated with relatively low fertility (e.g., Barthold et al., 2012; Bollen et al., 2007; Fieder and Huber, 2007; Shenk, 2009; Skirbekk, 2008). However, some studies, after taking into account resource availability measured by husbands' income, have argued that the fertility-status relationship remained positive (Bereczkei and Csanaky, 1996; Fieder et al., 2005; Hopcroft, 2006; Huber et al., 2010; Tsou et al., 2011; Weeden et al., 2006). Huber et al. (2010), using the sample of US couples, revealed that the overall income of the married couples as well as wives' income were negatively associated with number of children. Furthermore, Barthold et al. (2012) found that men with high-income partners had lower lifetime reproductive success than men who had partners with a lower income. The current findings of the relationship between spousal difference in social class and the number of children indicated that husbands from lower social classes who married wives of higher social classes tended to have higher fertility. The relationship remained significant when other variables were included in the full model. Our findings support Hopcroft's (2006) suggestion that it is not the socioeconomic status and income of women themselves that promotes their reproductive success, but that of their spouses. The present study is also in agreement with Zimmer's (1981) research on a random sample of 3,098 once-married women in Aberdeen, Scotland. He showed that, regardless of status of origin, women who were downwardly socially mobile by marriage had more children, and upwardly mobile women had fewer children than socially nonmobile ones.

Educational level is also known to be associated with fertility. Higher education has been almost universally found to be associated with lower fertility in the UK (e.g., Nettle, 2002a; Rendall and Smallwood, 2003) as well as studies based on the World Fertility Surveys and Demographic Health Surveys (Kremer and Chen, 2002) in developed and developing countries. The majority of studies have focused on women's educational attainment in relation to number of offspring rather than on partners' educational level simultaneously (Amin and Behrman, 2011; Cohen et al., 2011; Cygan-Rehm and Maeder, 2012; Weinberger 1987). However, there is an agreement that educationally homogamous marriages are more stable. As has been pointed out by Basu (2002) well-educated women have greater reproductive autonomy and lower fertility than less educated or uneducated women. This study showed that parents in more educated groups tended to have fewer children than men and women with a lower level of education or without qualifications, which is in agreement with many previous studies (Castro Martin, 1995; Cleland, 2002; Krzyżanowska and Mascie-Taylor, 2014; Skirbekk, 2008; Skirbekk et al., 2004; Smits et al., 2000). However, when spousal mean educational level as well as difference in education were included in the full Log Normal model the relationship disappeared.

In most societies, men marry younger women and women marry older men, which is attributed to men selecting young women due to their high reproductive potential and women preferring older men due to their resources and high social status. Using data from the three seventeenth- through nineteenth-century Sami population in Northern Finland, Helle et al. (2008) found that men maximized their offspring count by marrying women approximately 15 years younger. Bereczkei and Csanaky (1996) reported that in Hungary men marrying younger women had significantly more children than men who married older women. Similarly, Manning and Anderton (1998) using English data, reported a maximum offspring count when the husband was 2–3 years older than his wife. In contemporary Swedish data Fieder and Huber (2007) found that offspring count was maximized for men marrying women 4 years younger, and for women marrying men 6 years older. Tsou et al. (2011), using 1978–2006 national birth register data for Taiwanese women indicated that the positive relationship between parental age difference and offspring count can be largely attributed to the higher reproductive success of women who gave birth at younger ages. After controlling for a woman's reproductive value (measured by age at first birth), an older husband was associated with fewer offspring and number of children decreased with woman's age at first birth. In this study, the difference in age between spouses was not significantly related to fertility, while as mean age increased, so does fertility. Furthermore, almost 17% of variation in fertility was explained by mean age.

This article also adds to the growing evidence that the relationship between stature and fertility varies between populations in both men and women. For example, Pawłowski et al. (2000) analyzed data on 4,419 healthy men aged 25–60 between 1983 and 1989 from Wroclaw, Poland and found that men with children were significantly taller than childless men, while an American study found that tall members of the United States Military Academy at West Point had a greater number of children (Mueller and Mazur, 2001). A positive association was also found between stature and fertility in rural! Kung san men from Namibia (Kirchengast and Winkler, 1995), as well as in Gambian (Sear, 2006), Guatemalan Indian (Martorell et al., 1981), and rural Guatemalan (Pollet and Nettle, 2008) women. However, no relationship between height and fertility has been found in a number of studies involving men (e.g., Genovese, 2008; Goldstein and Kobyliansky, 1984; Kirchengast, 2000; Lasker and Thomas, 1976; Mueller et al., 1981; Nettle, 2002a; Sear, 2006; Winkler and Kirchengast, 1994) and women (Clark and Spuhler, 1959; Helle, 2008; Lasker and Thomas, 1976; Mueller, 1979; Mueller et al., 1981; Nenko and Jasieńska, 2009; Scott and Bajema, 1982; Silventoinen et al., 2013). Conversely, studies on a large sample of Harvard alumni (Vetta, 1975) and a Wisconsin longitudinal sample of men (Stulp et al., 2012a) showed an inverse U-shaped relationship between height and number of children such that men of average height were more likely to have a higher fertility than either shorter or taller men. Similarly, Brush et al. (1983) in a sample of Papua New Guinean women found U-shaped association between height and reproductive performance with lower number of offspring at the extremes of height. In Western societies (Bailey and Garn, 1979, Byars et al., 2010; Deady and Law Smith, 2006; Stulp et al., 2012b) as well as in non-Western populations (Devi et al., 1985; Kirchengast, 2000; Kirchengast and Winkler, 1996), shorter women have been shown to have more children than taller women. Other studies (Nettle, 2002a) on the NCDS conducted on the cohort members, not their parents, and focused not only on fertile but childless individuals as well, found that men's height was not associated with number of children. There was only the trend for the taller men to have fewer children. The same study was done for women (Nettle, 2002b) and inverted U-shaped association between height and reproductive performance with lower number of offspring at the extremes of height was reported. The present study results are in agreement with those showing a negative relationship between fertility and men's height (Kirchengast and Winkler, 1995). The relationship between women's height and fertility was more diverse. It appeared that, on the one hand, there was a negative association between wives height and number of children with shorter women tending to have higher fertility. In addition, a U-shaped relationship between wives' height and number of children was found such that women of average height were more likely to have a lower fertility than either shorter or taller ones. The decreased reproductive success among taller women may be related to the positive relationship between height and socioeconomic status. It is well known that education, social class, and income are negatively associated with women reproductive success in Western populations, that is, well-educated and higher income women have less offspring (Hopcroft, 2006; Kravdal and Rindfuss, 2008; Nettle and Pollet, 2008). It is also well known that shorter women are at higher risk for complications during pregnancy (Bresler, 1962), and the need for an emergency Caesarean section (Stulp et al., 2011). Furthermore, shorter women are more likely to give birth to infants with a relatively low birth weight and relatively low Apgar scores (Camilleri, 1981; Casey et al., 2001), which both are predictors of child morbidity and mortality (Casey et al., 2001). The higher fertility among shorter women might be treated as a quantity–quality trade-off (Borgerhoff Mulder, 2000) between number of children and the quality of their somatic growth as well as cognitive abilities, and indicates a strategy to compensate for future or past child loss. Completed reproductive success is more likely to have been measured for shorter women who have menarche at an earlier age (McIntyre and Kacerosky, 2011), and thus have their first child at an earlier age (Helle, 2008), which may result in a negative association between women's height and number of offspring. As height has been shown to be related to the timing of births, it is possible that women who are born in later cohorts are taller than women born in earlier cohorts and thus, shorter women might potentially stop reproducing at an earlier age, because they were born in earlier cohorts. However, among women in the NCDS cohort, neither linear nor curvilinear evidence was found to support this hypothesis (not presented).

Assortative mating for physical characteristics such as height has been studied in many populations (Pearson and Lee—quoted after Beckman, 1962; Dalmia and Lawrence, 2001; Mascie-Taylor, 1987; Roberts, 1977; Seki et al., 2012) and most report evidence of some positive assortative mating. The median correlation for height assortative mating is about 0.2 (Susanne and Lepage, 1988) in European populations. More variable results were reported for non-European populations. For example, a positive assortative mating for height was found in Pakistan (Ahmad et al., 1985), Bolivia (Godoy et al., 2008) and Oaxaca, Mexico (Malina et al., 1983), whereas no correlation between height of spouses was found in Korea (Hur, 2003), Cameroon (Pieper, 1981), Gambia (Sear, 2006), as well as among Hadza hunter-gatherers from Tanzania (Sear and Marlowe, 2009). In Britain, spousal correlations for height range between 0.09 and 0.34 (Roberts, 1977; Spuhler, 1982). In this study, the extent of assortative mating for height was highly significant ($r = 0.28$).

It is well established within industrialized Western populations that males can maximize their reproductive success by going in search of youthful, fertile females, whereas females can maximize their reproductive success by preferring socially dominant and high-status males that are able to provide more resources (Pawłowski, 2000). Though several hypotheses (an assortative preference, male-taller, or female-shorter norm) have been put forward to account for height preferences in mate selection (Belot and Fidrmuc, 2010; Belot and Francesconi, 2006; Gills and Avis, 1980; Fink et al., 2007; Mascie-Taylor and Boldsen, 1988; Oreffice and Quintana-Domeque, 2010; Silventoinen et al., 2003; Stulp et al., 2013b, 2013c; Susanne and Lepage, 1988; Vaillant and Harrant, 2008), there is also evidence to suggest that women prefer men who are not too tall and men prefer women who are not too short—male-not-too-tall norm (female-not-too-short norm) (Courtiol et al., 2010; Fink et al., 2007; Salska et al., 2008; Stulp et al., 2013c). The hypothesis suggested by Pawłowski (2003) refers to a situation when partners prefer a spouse whose height difference is close to the average population dimorphism. He showed that both shorter men and taller women tend to prefer smaller partner height differences than taller men and shorter women, who both prefer larger partner height differences. Given such findings, one might expect that partners' preferences for height difference close to the average population dimorphism would translate into higher marriage stability as well as higher reproductive success. The current study, showing a primarily U-shaped relationship between parental height difference and fertility with the lowest number of children among couples whose height difference was about 15 cm (very close to the average height difference in this cohort, which is 12.5 cm), did not confirm this expectation. Shorter men are usually considered less desirable as mates than average height and taller men (Courtiol et al., 2010; Stulp et al., 2013a), and short men may be more likely to be paired with spouses who also score low on the marriage market (Oreffice and Quintana-Domeque, 2010). Thereby, shorter men may have fewer children than men who are taller. A recent study by Weitzman and Conley (2014) using data from 4,500 families between 1968 and 2011 (the Panel Study of Income Dynamics) showed that short men were more likely to enter relationships in which they were the same height or shorter than their spouses. In addition, it appeared that taller men tended to couple with older women, while shorter men coupled with younger women. Furthermore, Weitzman and Conley (2014) noticed that short men tended to be in more stable marriages than average and tall men, and the incidence of divorce was found to be 32% lower among short than among average men. In this context, our findings of higher fertility among shorter husbands and taller wives couples are not surprising. Conversely, our results showed higher fertility among taller husbands and shorter wives as well, which reflects a wide range of advantages of taller men. Height is an attribute which women find attractive in men as they appear to be indicators of a man's physical and genetic quality (Gangestad and Simpson, 2000). Taller men have higher starting salaries (Loh, 1993) and higher overall income (Judge and Cable, 2004). They are more socially promoted, and tend to occupy higher positions that require better qualifications (Schumacher and Knussmann, 1979; Mascie-Taylor, 1984). Taller men are preferred as mating and marriage partners, they marry younger and reproduce earlier (Gustavsson et al., 2008; Herpin, 2005; Low, 1998).

The present study clearly showed that there is a significant negative association between spousal mean height and number of children per se. However, after controlling for region, spousal age, educational level and social class the differences in height between spouses was not significantly related to fertility. Instead of height, spousal mean social class as well as difference in social class remained highly significant, with husbands from lower social classes who married wives of higher social classes having higher fertility.

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