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Effect of marital distance on birth weight and length of offspring

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ABSTRACT: Marital distance (MD), the geographical distance between birthplaces of spouses, is considered an agent favouring occurrence of heterosis and can be used as a measure of its level. Heterosis itself is a phenomenon of hybrid vigour and seems to be an important factor regulating human growth and development. The main aim of the study is to examine potential effects of MD on birth weight and length of offspring, controlling for socioeconomic status (SES), mother's age and birth order. Birth weight (2562 boys and 2572 girls) and length (2526 boys, 2542 girls) of children born in Ostrowiec Swietokrzyski (Poland) in 1980, 1983, 1985 and 1988 were recorded during cross-sectional surveys carried out between 1994-1999. Data regarding the socio-demographic variables of families were provided by the parents. Analysis of covariance showed that MD significantly affected both birth weight and length, allowing for sex, birth order, mother's age and SES of family. For both sexes, a greater marital distance was associated with a higher birth weight and a longer birth length. Our results support the hypothesis that a greater geographical distance between the birth places of parents may contribute to the heterosis effects in offspring. Better birth outcomes may be one of the manifestations of these effects.

KEY WORDS: heterosis, birth weight, birth length, marital distance

Introduction

Systematic studies on low birth outcomes and low birth weight in particular, have pointed out multiple risk factors of fetal growth retardation. Well documented examples of these factors include, among others, low social class (Karim and Masci-Taylor 1997), high birth order and maternal age (Khoshonood et al. 2005), as well as other paternal factors such as maternal size (Spencer and Logan 2002; Pölziberger et al. 2017) and parental height (Shah 2010).

Relatively little is known, however, about the possible effect of marital

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distance on birth outcomes in humans. Marital distance can be expressed as the direct geographical distance between the birthplace of spouses (Mascie-Taylor 1986) and to some extent, one can assume that it approximates the process of marital migration. It is suggested that such short-range migrations, leading to a choice of mate, affects the genetic structure of populations (Mascie-Taylor and Little 2004). Possible phenotypic effects of this process on fetal growth may be manifested through heterosis. Heterosis is a phenomenon firstly described by Shull, and refers to the higher vigour of offspring from crosses between two separate breeding lines (Bodmer and Cavalli-Sforza 1976; Wright 1977). Possible benefits of heterosis are attributed to the positive effects of heterozygosity, such as suppression of deleterious recessive alleles and/or the overdominance of heterozygotic genotypes over homozygotic ones (Wright, 1977; Crow1998). If fitness in crossbreeds is higher than in purebred individuals, heterosis can be favoured by evolutionary processes (Dobzhansky 1970).

In humans, a good basis for heterosis can be constituted by regional micro-differentiation in gene frequencies and a higher probability of kinship (Wright 1943; Kimura and Weiss 1964; Friedlaender 1971; Morton 1977) leading to consanguineous marriages between individuals who live in close geographical proximity (e.g. Barrai et al. 1962; Cavalli-Sforza and Bodmer 1971; Crognier 1977; Reddy 1988). By definition such conditions may contribute to inbreeding followed by a local increase in homozygosity (Cavalli-Sforza and Bodmer 1971). Consequently, marital migration and mating between parents whose birthplaces are geographically distant, may result in higher offspring heterozygosity and the positive effect of heterosis.

The main aim of the study is to examine the potential effects of geographical distance between parents' birthplaces (i.e. marital distance) on birth weight and length of offspring. We expect that children whose parents come from geographically distant birthplaces, have better birth outcomes (i.e. are heavier and longer) when controlling for several other factors which may potentially influence pregnancy outcomes.

Material and methods

Data concerning birth weight (2562 boys and 2572 girls) and length (2526 boys, 2542 girls) of children born in Ostrowiec Swietokrzyski in 1980, 1983, 1985 and 1988 were recorded during cross-sectional surveys carried out between 1994–1999. Questionnaires were distributed among the parents with a request to complete them. Birth outcome data came from the children's health cards. The socio-demographic data of families and birthplaces of parents were provided by the questionnaires. The distance between the birthplaces of parents (marital distance) was scored in three categories as follows: less than 25 kilometers, between 25 and 100 kilometers, more than 100 kilometers. The socio-economic status (SES) was presented by first factor scores derived from principal component analysis (PCA) encompassing such factors as parental education, family size, living conditions and household possessions. The eigenvalue of the analyzed factor amounted to 2.73 and explained 54.62% of common variation in SES. The score of the first factors were then used as an independent variable in further analysis.

The analysis of covariance was conducted separately for birth weight and length as dependent variables. Marital distance, participants' sex and birth order were independent variables and SES and mother's age were confounders. Significant second order interactions were presented on graphs. All analysis was carried out using STATISTICA 13.1 (Dell Inc. 2016).

Results

Table 1 shows descriptive statistics of the birth weight and length of boys and girls. The boys were significantly heavier and longer than the girls at birth, which confirms well-known findings from previous studies.

The results of the analysis of covariance are shown in Table 2. Marital distance significantly affected both birth weight and length, allowing for sex, birth order, mother's age and SES of the family. The greater the marital distance, the higher the birth weight and length in both sexes (Figs 1 and 3). Statistically significant second order interactions between marital distance and birth order for the birth length showed that the marital distance effect largely disappeared for children after the third delivery (Fig. 4). Children born third in line or subsequent offspring, having parents with above 100 km marital distance, had a smaller birth length compared to children from the 20–100 km category. No such effect was observed for the birth weight (Fig. 2).

Discussion

The study has identified a new significant factor influencing fetal growth. Marital distance, defined as the geographical distance between parents' birthplaces, significantly affected both birth weight and length in boys and girls. Both measurements increased along with the increase in marital distance, independently from sex and birth, allowing for mother's age

Table 1. Means and standard deviation values of birth weight and length in boys and girls

	Birth weight (g)			Birth length (cm)		
	N	Mean	SD	N	Mean	SD
Boys	2562	3503.6	491.3	2526	54.4	3.57
Girls	2572	3276.6	468.4	2542	52.9	3.19
	$t = 16.91$ $p < 0.001$			$t = 14.93$ $p < 0.001$		

Table 2. Results of analysis of covariance with SES and mother's age as confounding variables and sex, birth order and marital status as independent variables for birth weight and length

	Birth weight		Birth length	
	$\chi 2$ Wald's	p	$\chi 2$ Wald's	*p*
SES	392.71	<0.001	553.12	<0.001
Mother's age	0.10	0.7518	4.08	<0.05
1. Sex	106.68	<0.001	92.09	<0.001
2. Birth order	86.70	<0.001	110.84	<0.001
3. Marital distance	81.89	<0.001	62.78	<0.001
1 × 2	15.77	<0.001	7.24	<0.05
1 × 3	0.58	0.7489	4.83	0.0892
2 × 3	4.12	0.3905	15.50	<0.01

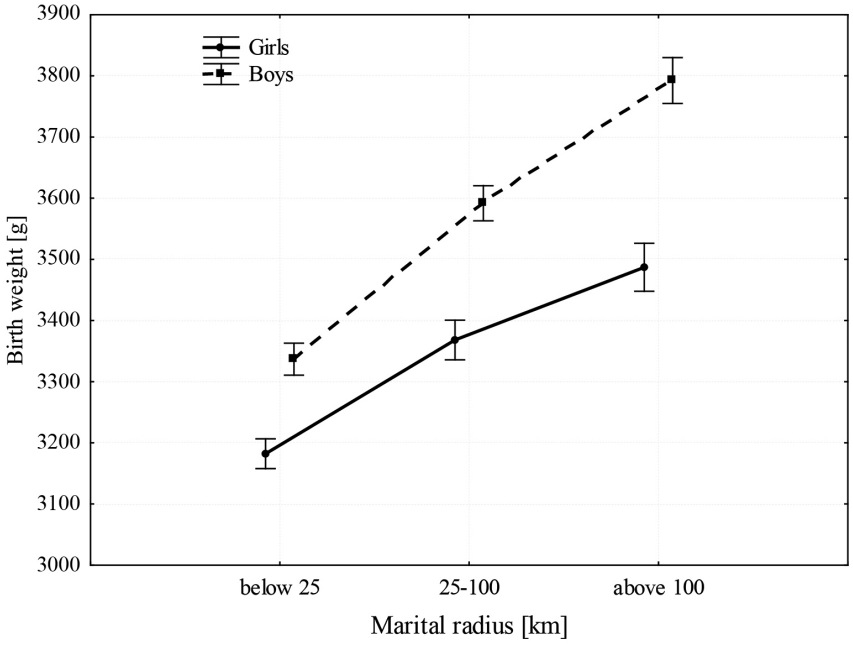

Fig. 1. Means (+/– SE) birthweight by sex and marital distance

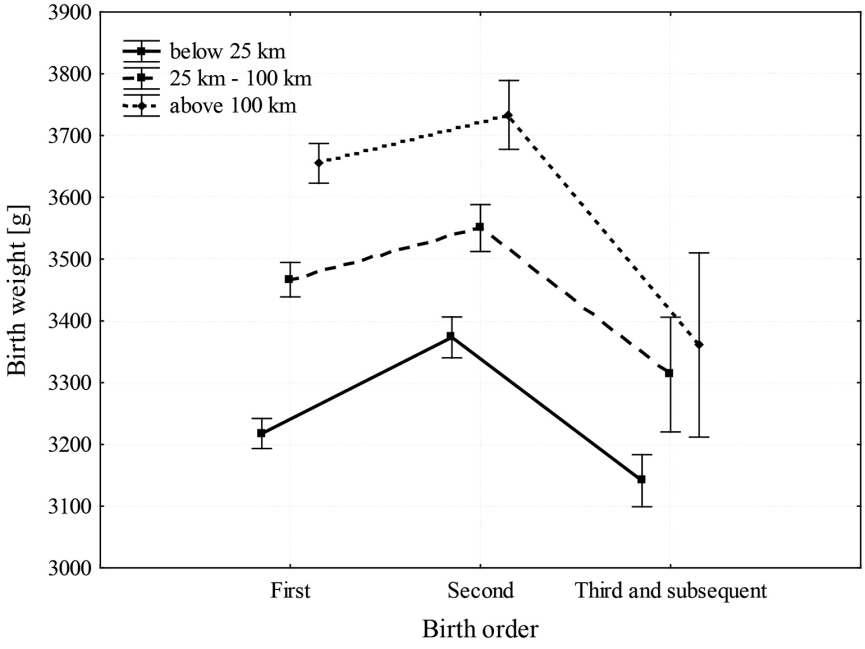

Fig. 2. Means (+/– SE) birthweight by birth order and marital distance

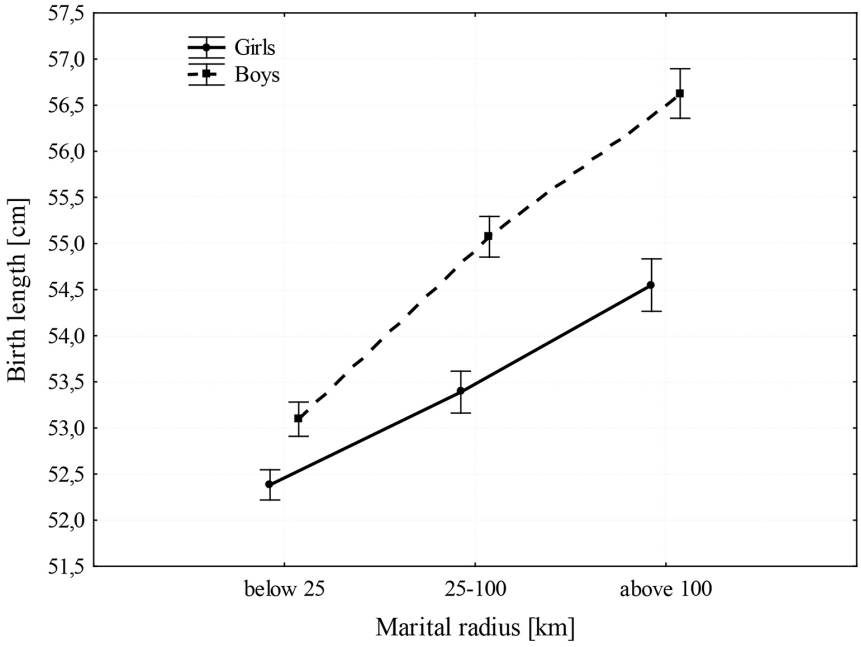

Fig. 3. Means (+/– SE) birth length by sex and marital distance

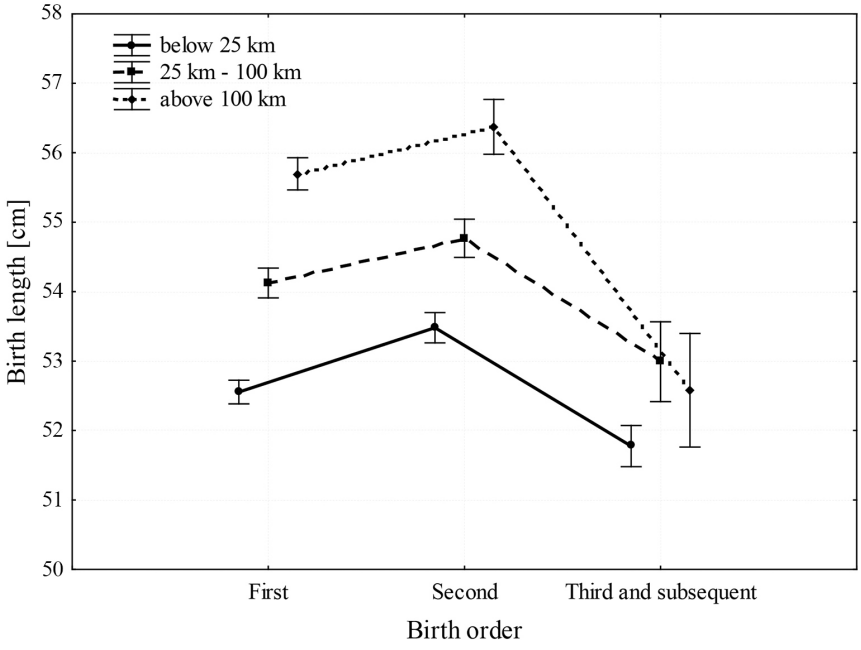

Fig. 4. Means (+/– SE) birth length by birth order and marital distance

and SES of the family. Only one second order interaction between marital distance and birth order in birth length was significant.

The positive impact of heterosis on children's fitness may be a consequence of both suppression of deleterious recessive alleles from one parent by dominant alleles from the other, as well as the superiority of heterozygotes over homozygotes at given loci (see: Wright 1977; Crow 1998). Thus, in both cases possible benefits of heterosis, such as better growth and development outcomes may be attributed to a higher level of heterozygosity of offspring whose parents' marital distance was greater (for more discussion see: Kozieł et al. 2011).

The second mechanism related to marital distance and potentially influencing fetal growth, is described by the selective migration concept. Migration often carries numerous costs, both genetic, somatic as well as cultural, involving life style changes and adaptation to different conditions in a new environment (Fix 1999; Mascie-Taylor and Little 2004). For that reason, it might be expected that migrants would possess select personal characteristics which facilitate their mobility Consequently, biological traits of migrants may be different from the same traits of non-migrants (see: Mascie-Taylor and Little 2004). Possibly the first study which demonstrated such phenomena in stature was conducted by Fishberg (1905), who examined several groups of European immigrant Jews to New York. In most cases they were found to be taller when comparing them to their counterparts in the native population. More recently, studies on rural-urban migration indicates that migrants are slimmer (Verheij et al. 1998; Lyngdoh et al. 2006) and generally have better health (Verheij et al. 1998). Also Szklarska et al. (2008), who examined inhabitants of the city of Wrocław (Poland), aged 40–50, demonstrated that those who had come to the city at age 16 years or more, generally have more biologically favourable anthropological and physiological characteristics relating to health status when comparing to non-migrants. The positive effects of selective migration may be also visible in the second generation of migrants (migrants' children) resulting, for instance, in better birth outcomes.

According to our knowledge, there is only one study directly reporting the effect of marital distance on birth outcomes in offspring. In the Brazilian population of white children, birthweight was negatively related to the marital distance of children's parents. No statistically significant effect was found for black children (De Araujo and Salzano 1975). Our results showing the positive relationship between marital distance and birth weight and length do not support the Brazilian findings.

The effect of marital distance on postnatal growth was has been examined by several authors. Wolanski et al. (1970) found that children's height, relative body mass and chest circumference increased with greater marital distance. A similar effect for stature and weight was absent in children studied by Schmitt et al. (1991). The authors, however, observed reduced variability for both body parameters in 'the distant children' and such a phenomenon can be associated with heterosis (Schmitt et al. 1991). Another, more recent study by Koziel at al. (2011), reported the significant effect of marital distance on the growth of boys and girls, controlling for socio-economic status and mid-parental height, as a genetic contribution to the height var-

iation. The authors showed a gradual increase of the stature of boys and girls with the greater distance between birthplaces of parents. In the interpretation of their findings, the authors referred to the increased level of heterosis associated with greater marital distance.

Our study is subject to several limitations. For instance, it is generally known that gestational age at delivery is one of the major determinants of infant birthweight (Cnattingius et al. 1999). Unfortunately, in our data set we did not have such information. However, it is reasonable to assume that significant differences between marital distance and gestational age are highly unlikely. Thus, be believe that our results show the real effect of marital status on birth outcomes. It is also well known that smoking during pregnancy seriously affects birthweight and causes preterm delivery (Vielwerth et al. 2007; Heaman et al. 2013). Our data also prevented us from having direct control of maternal and/or paternal smoking during pregnancy. In the statistical analysis, however, we used the socio-economic status of the family, which included parental education, as a covariate. There is evidence that a smoking habit highly correlates with the level of education, and that it is more likely that mothers with higher education give up smoking during pregnancy (Penn and Owen 2002). Therefore, the adverse effects of parental smoking on fetal development were at least partially controlled by the socioeconomic status of the households. Further, we used geographical distance between parental birthplaces as a proxy measure of offspring heterozygosity. This is only approximate measure and only indirectly indicates individuals' allele diversity and its influenced on physical growth.

In summary, our study identifies geographical distance between birthplaces of parents as another factor influencing children's birth outcomes. We showed that both birth weight and length are positively associated with marital distance. Since greater geographical separation of parents may contribute to the higher offspring heterozygosity, we conclude that the observed effects may be attributed to the heterosis.

Authors' contributions

SK worked out the idea, designed and provided statistical analysis, prepared first draft, edited final version; DD worked out the idea, helped in analysis, prepared the draft; AD-D prepared the draft, interpreted the results; MZ collected data and prepared them for analysis.

Conflict of interest

The authors declare that there is no conflict of interests regarding publication of this paper.

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