Being born after your brother is not a disadvantage: Reproductive success does not depend on the sex of the preceding sibling

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Abstract

Objectives: Males, as the more expensive sex, constitute a drain on maternal resources and elicit an immune response during pregnancy, which may have negative consequences on subsequent siblings. Thus, the sex of the preceding sibling may influence an individual's fitness, and, in fact, individuals born after a brother have been shown to have lower reproductive success in historical populations. The aim of the present study is to examine whether being born after a brother versus after a sister differentially impacts reproductive outcomes in a contemporary population.

Methods: A questionnaire was used to collect data on reproductive health and family history from 951 women and 380 men between 20 and 92 years of age in villages throughout the Mogielica Human Ecology Study Site in southern Poland. Number of children, number of sons and daughters, age at menarche, age at marriage, age at menopause, and age at first and last reproduction were tested as components of reproductive success.

Results: The sex of one's preceding sibling had no statistically significant impact on any of the reproductive characteristics tested.

Conclusions: Our results suggest that potential immunological and nutritional disadvantages experienced during prenatal life by individuals born after male siblings do not have long-lasting effects in modern, well-nourished populations.

Introduction

Studies conducted on data from historical populations demonstrate that an individual's reproductive success may be influenced by the sex of his or her preceding sibling. In pre–industrial Finland, both men and women born after a brother had diminished lifetime reproductive success, including a lower chance of reproducing, a later age at first reproduction, and longer interbirth intervals (Rickard et al., 2007; Rickard et al., 2009). This relationship may be explained by the fact that producing a son has a higher energetic cost for a mother than producing a daughter. Male infants are characterized by a faster intrauterine growth rate (Marsál et al., 1996) and a heavier birth weight (de Zegher et al., 1999). In addition, mothers pregnant with sons have a 10% higher energy intake than those pregnant with daughters, suggesting that male fetuses require more energy than female fetuses (Tamimi et al., 2003). These energetic costs associated with male offspring, which may result in maternal depletion, could also have a negative effect on subsequent siblings.

Besides energetic costs, male fetuses may also have an immunological impact on their mothers. It has been hypothesized that a maternal immune response to the H–Y antigens occurs during pregnancy with a male fetus, and its effect may last for many years after pregnancy. H–Y antigens (which are located only on male cell surfaces) may enter a mother's circulatory system and lead to reduced birth weight in successive males born after a brother (Côté et al., 2003). Reductions in birth weight have also been documented in girls born after brothers (Nielsen et al., 2008), suggesting that both immunological and energetic mechanisms contribute to the compromised biological condition of subsequent siblings. Moreover, Nielsen et al. (2010) showed that the risk of stillbirth was higher in women who have previously given birth to a boy, pointing to the maternal immune response to the male–specific antigens as a possible mechanism.

In contemporary populations, only the effect of total number of older brothers on an individual's reproductive success was investigated (Milne and Judge, 2011; Mace, 1996), but no studies, to our knowledge, have examined the impact of the preceding sibling's sex on reproductive success. We investigate what effect the sex of the preceding sibling has on components of reproductive success (i.e. number of children, age at

menarche, age at first and last reproduction) of men and women in a contemporary Polish rural population.

Methods

The study was conducted between 2003 and 2013 in several villages characterized by a high birth rate within the Mogielica Human Ecology Study Site in southern Poland (Jasienska, 2013. p. 29-32). Most families in this population still practice small-scale subsistence farming, in addition to other income-generating activities. Many people are involved, at least seasonally, in activities requiring high levels of energy expenditure, but due to sufficient energy intake have good nutritional status (Jasienska and Ellison, 2004; Jasienska 2013). A questionnaire was used to gather information on reproductive and family history from 1331 individuals 20–92 years old. Exclusion from the study occurred if there was a lack of information on birth order (N=165) and if the individual was an only child (N=30) or the first–born in their family (N=274). The study sample was divided into 4 groups based on the sex of the individual and the sex of his or her maternal preceding sibling: 300 women born after a sister, 325 women born after a brother, 121 men born after a sister, and 116 men born after a brother.

All the differences in reproductive characteristics between groups of men and women born after a brother versus those born after a sister were tested with analyses of covariance (ANCOVA), with age as a potential confounder. Previous studies, including a study conducted at our study site, show that education may impact life history events (Colleran et al. 2014). Therefore, the duration of education (number of years) was included in all models, except for models of age of menarche and menopause. The differences in age at marriage and age at first and last reproduction were tested for groups of individuals born after a brother versus a sister, separately for men and women. Additionally, we tested differences in age at menarche, age at natural menopause, and mean interbirth intervals for women. Lastly, we analyzed differences in number of children, number of sons (controlled for number of daughters), and number of daughters (controlled for number of sons) separately for men and women in models with Poisson distributions.

For the analysis of age at menopause, we included only women who reported a natural cause of menopause (119 born after a brother and 102 born after a sister). In the

analyses of number of children, number of daughters, number of sons, and age at last reproduction, we included only 188 women who went through a natural menopause and whose husbands survived at least until their menopause. In similar analyses for men, we included 54 men whose wives survived until natural menopause. We included the criteria of having a surviving spouse because death of the spouse negatively affects chance of reproduction. Statistical analyses were conducted using Statistica package version 9.0.

Results

Individuals born after a sister did not differ in their reproductive characteristics from those born after a brother. The sex of an individual's preceding maternal sibling had no statistically significant effect on age at marriage, age at first and last reproduction, number of children, number of sons (controlling for number of daughters), or number of daughters (controlling for number of sons) (Table 1). P values ranged from 0.12 to 0.96 for the different reproductive characteristics. There was also no statistically significant difference in age at menarche, age at natural menopause, or mean interbirth intervals between women born after sister and women born after brother.

Table 1. Comparison of reproductive characteristics of groups of men and women born after a brother versus born after a sister. Predicted values based from models adjusted for age and years of education.

	Women				Men			
	Born after				Born after			
	Brother	Sister			Brother	Sister		
	adj mean(SE)	adj mean(SE)	F/χ^2	P	adj mean(SE)	adj mean(SE)	F/χ^2	P
Age at menarche	14.6(0.08)	14.6(0.08)	0.006	0.96*				
Age at marriage	23.3(0.24)	22.9(0.24)	0.76	0.39	26.4(0.34)	27.1(0.42)	1.23	0.27
Age at first reproduction	23.9(0.23)	23.7(0.22)	0.24	0.62	27.3(0.39)	28.2(0.43)	2.39	0.12
Number of children	4.5(0.24)	4.7(0.24)	0.35**	0.55†	4.5(0.38)	5.0(0.61)	0.09**	0.76††
Number of sons	2.6(0.19)	2.5(0.17)	0.70**	0.40†	2.4(0.29)	2.5(0.38)	0.06**	0.81††
Number of daughters	2.1(0.14)	2.0(0.16)	0.01**	0.94†	2.1(0.24)	2.5(0.36)	0.30**	0.58††
Age at last reproduction	34.4(0.62)	34.5(0.62)	0.42	0.52†	39.8(1.22)	39.7(1.14)	0.50	0.48 ††
Mean interbirth interval	40.3(2.21)	41.3(3.34)	0.04	0,85†				
Age at natural menopause	51.0(0.37)	50.7(0.34)	0.42	0.52*				

† included 102 women born after a brother and 86 born after a sister, who had natural menopause and whose husbands survived until their menopause

††included 28 men born after a brother and 26 born after a sister, whose wives survived until natural menopause

* adjusted only for age

** results based on analyses with Poisson distribution

Discussion

In our study the sex of one's preceding sibling did not significantly influence the components of reproductive success (number of children, number of sons, number of daughters, age at menarche, age at marriage, age at menopause, and age at first and last reproduction) in the contemporary Polish rural population. Previous studies have demonstrated that such a relationship exists in historical populations. For example, men and women in pre–industrial Finland experienced decreased lifetime reproductive success, including a lower chance of reproducing, a later age at first reproduction, and longer interbirth intervals when born after a brother (Rickard et al., 2007; Rickard et al., 2009). Additionally, Nitsch et al. (2013) found that while lifetime fitness was reduced by the presence of same–sex elder siblings, it was increased by the presence of opposite–sex siblings.

In modern populations, the sex of one's preceding sibling has been shown to have an effect on birth weight, with male newborns born after older brothers weighing less at birth than those born after older sisters (Côté et al., 2003). Furthermore, in adulthood, both males and females born after a brother were shorter than individuals born after a sister (Rickard, 2008). Since men's adult height is a known correlate of reproductive success (Pawłowski et al., 2000), it is possible that the sex of the preceding sibling could have an effect on reproductive outcomes. A recent study on over 500,000 Swedish men confirmed that those born after a brother were lighter and shorter at birth than those born after a sister (Jelenkovic et al., 2014). However, reported differences, while statistically significant, were most likely too small (10 g and 0.04 cm) to have any biological impact on the condition of an individual.

Sons are more energetically demanding than daughters (Marsál et al., 1996; Tamimi et al., 2003), but these higher energetic costs are especially evident in mothers with poor nutrition (Jasienska, 2013, p. 131-170). In this well-nourished contemporary Polish population, adequate nutrition (Nenko and Jasienska, 2009) could potentially offset the costs experienced by a mother during the previous pregnancy with a male fetus. Therefore, it is likely that a fetus during next pregnancy would not be affected.

Cultural norms in historical populations, where first–born or elder male offspring received most of the family's resources, may have contributed to their heightened reproductive success. However, these customs are less prominent in our contemporary Polish population. Nowadays in rural Poland, older male children are not heir to their entire family's inheritance. Therefore, later born children are as likely to find a mate and start a family as their elder brother. The relevant advantages in nutrition and cultural custom may explain why being born after a brother does not appear to be a reproductive handicap in this well-nourished contemporary rural population.

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