First-borns have greater BMI and are more likely to be overweight or obese: a study of sibling pairs among 26,812 Swedish women

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ABSTRACT

Background: A number of large studies have shown phenotypic differences between first-borns and later-borns among adult men. In this study, we aimed to assess whether birth order was associated with height and BMI in a large cohort of Swedish women.

Methods: Information was obtained from antenatal clinic records from the Swedish National Birth Register over 20 years (1991–2009). Maternal anthropometric data early in pregnancy (at approximately 10–12 weeks of gestation) were analysed on 13,406 pairs of sisters who were either first-born or second-born (n=26,812).

Results: Early in pregnancy, first-born women were of BMI that was 0.57 kg/m^2 (2.4%) greater than their second-born sisters ($p<0.0001$). In addition, first-borns had greater odds of being overweight (odds ratio 1.29; $p<0.0001$) or obese (odds ratio 1.40; $p<0.0001$) than second-borns. First-borns were also negligibly taller (+1.2 mm) than their second-born sisters. Of note, there was a considerable increase in BMI over the 18-year period covered by this study, with an increment of 0.11 kg/m^2 per year ($p<0.0001$).

Conclusions: Our study corroborates other large studies on men, and the steady reduction in family size may contribute to the observed increase in adult BMI worldwide.

What is already known on this subject?
A number of studies have shown phenotypic differences between first-borns and later-borns. In adulthood, first-born men were observed to be taller, heavier and of greater body mass index than later-borns.

What does this study add?
Our study on 13,406 sister pairs among Swedish women corroborates other large studies on men, as we show that first-born women had greater body mass index and were more likely to be overweight or obese than their second-born sisters.

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INTRODUCTION

There has been a steady decline in birth rates worldwide, especially in Europe and many Asian countries [1]. Numerous factors account for this reduction in birth rates, such as one-child government policies, personal choice, and economical constraints. Consequently, the number of one-child families is steadily increasing, so that, inevitably, there has been a progressive increase in the proportion of first-borns in the world's population.

A number of studies have reported phenotypic differences between first-borns and later-borns in childhood and adulthood [2-7]. Studies have shown that first-born children were taller [2 3], with a progressive reduction of in height to second and third-borns [3]. In adulthood, first-born men were observed to be taller, heavier and of greater body mass index (BMI) than later-borns [5-7]. In particular, a Swedish study on one million men showed that increasing birth order was associated with lower BMI [5].

It seems that all large studies examining the effects of birth order on adult BMI and stature have been carried out on men. Similar data in adult women are particularly scarce, and it is of interest to identify whether similar patterns are also observed amongst females. This is important as there is well-described sexual dimorphism in association with early life events, with contrasting effects on long-term health and disease observed in men and women [8]. Thus, data on men cannot be readily extrapolated to women. As a result, in this study we aimed to assess whether birth order is associated with height and BMI in a large cohort of Swedish women.

METHODS

Ethics approval

Ethics approval for this study was provided by the Ethics Committee of the Medical Faculty of Uppsala University. Informed consent was not needed and was therefore not requested from participants, as this is a register-based study where participants were not contacted, and analyses involved anonymized data.

Study design

The Swedish Birth Register (kept by the National Board of Health and Welfare) was started in 1973, and contains data on more than 99% of all births in Sweden [9]. In Sweden, information is collected prospectively during pregnancy, beginning with the first antenatal visit. Data are recorded on maternal demographic factors and reproductive history, as well as complications during pregnancy, delivery, and the neonatal period. This information is then forwarded to the birth registry. All births and deaths are validated every year against the Register of the Total Population (kept by Statistics Sweden), using the mother’s and the infant’s unique personal identification number, which is assigned at birth to each Swedish resident.

This study examined data collected at the first antenatal visit on all Swedish women aged over 18 years, between 1991 and 2009. Antenatal clinics were mostly during 10–12 weeks of gestation, with 95% of all clinics occurring prior to 15 weeks of gestation. At the first antenatal visit, women were interviewed about current heath, lifestyle, and family history. Weight was measured and current height was self-reported or measured. Exclusion criteria were birth higher than second order, birth to non-Nordic mothers, congenital malformations (in either women or their mothers), and gestational age outside the term range (37 0/7 – 41 6/7 weeks of gestation). In addition, only singleton women aged 18 years or older at the time of first antenatal clinic were included in the study. Further, women were only included if also born to a singleton mother who was aged 18 years or older at their first antenatal clinic. For analyses, we selected all those sibling pairs with complete anthropometric data.

BMI was calculated, with overweight defined as ≥25.0 kg/m^2 and obese ≥30.0 kg/m^2. Tall adult stature was defined as height greater than 2 standard deviation scores (SDS) (>179 cm). Information on birth weight, birth length, and gestational age was obtained from the Birth Register, and the ponderal index subsequently calculated.

Statistical analyses

Data between first- and second-borns were compared using linear mixed regression models. Mother identification number was included as a random factor to identify sibling clusters, while sibship size (i.e total number of siblings) was included as a covariate. When assessing BMI as an outcome, the year of maternal birth (to account for the secular increase in adiposity) and woman's age at pregnancy were also added as covariates. Logistic regressions based on similar models were run to compare rates of overweight and obesity within sister pairs. Mediation analyses were also carried out including birth weight as a covariate. Statistical tests were two-tailed and significance level maintained at 5%. Data are presented as means ± standard errors, while results from logistic regression are expressed as odds ratios (OR) and 95% confidence intervals. All statistical analyses were carried out in SAS v.9.4 (SAS Institute, Cary, NC, USA).

RESULTS

There were 303,301 Swedish females born in 1973–1988 who gave birth to a child in 1991–2009. However, 96,791 failed to meet inclusion criteria, so that there were 206,510 eligible women who were first- or second-borns. We subsequently analysed data on 13,406 sister pairs (n=26,812) with complete anthropometric information available. At birth, there were some subtle differences between sisters (Table 1). First-borns were 86 g (2.5%) lighter with a marginally lower ponderal index (-0.05 g/cm^3) (Table 1).

Table 1. Anthropometric characteristics at birth and in early pregnancy (10–12 weeks of gestation) for first- and second-born sisters. Data are means ± standard errors adjusted for confounding factors.

		First-borns	Second-borns	p-value
Birth	Gestational age (weeks)	39.68 ± 0.01	39.55 ± 0.01	<0.0001
	Birth weight (g)	3404 ± 4	3490 ± 4	<0.0001
	Ponderal index (g/cm^3)	2.72 ± 0.00	2.77 ± 0.00	<0.0001
Early pregnancy	Age (years)	26.24 ± 0.03	25.22 ± 0.03	<0.0001
	BMI (kg/m^2)	24.35 ± 0.04	23.78 ± 0.04	<0.0001
	Height (cm)	167.15 ± 0.01	167.03 ± 0.01	0.026
	Weight (kg)	68.01 ± 0.12	66.45 ± 0.12	<0.0001

Early in pregnancy (10-12 weeks of gestation), first-born women were of BMI that was 0.57 kg/m^2 (2.4%) greater than their second-born sisters (p<0.0001; Table 1). First-borns also had greater odds of being overweight (OR 1.29 (1.21–1.38); p<0.0001) or obese (OR 1.40 (1.26–1.54); p<0.0001) than second-borns. Lastly, first-borns were negligibly taller (+1.2 mm) than second-borns (Table 1).

Unadjusted analyses lessened the magnitude of the difference in BMI (0.17 kg/m^2; p<0.0001) and eliminated the previously minor difference in height (0.7 mm; p=0.20). Of note, there was a considerable increase in BMI over the 18-year period covered by this study, with an increment of 0.11 kg/m^2 per year (p<0.0001). In addition, as women aged there was a corresponding increase in BMI of 0.05 kg/m^2 per year (p<0.0001).

Sibship size was not associated with BMI or with the odds of being overweight or obese (data not shown). However, increasing sibship size was associated with a decrease in height (ß=-0.128; p=0.003) and lower odds of a woman being of tall stature (OR 0.84 (0.74–0.95); p=0.008).

DISCUSSION

In the largest such study to date, we have shown that first-born women had greater BMI and were more likely to be overweight or obese than their second-born sisters. These observed associations between birth order and female adiposity corroborate data from previous studies on women that were not sibling pairs. In Italy, among 383 overweight or obese women first-borns had more body fat and had BMI that was 4 kg/m^2 greater than later-borns [10]. Similarly, a study on 171 young adult women in India showed that birth order was negatively correlated with BMI and fat mass [11]. Among 1,458 teenage girls in Poland, there was no difference in BMI SDS between first- and second-borns, but first-born girls were 1.5 times more likely to be obese than later-borns [12].

Thus, our data on Swedish women (and those from smaller previous studies) are in agreement with findings of increased adiposity in first-born adult men [5 13]. Jelenkovic et al. showed in over one million Swedish men that birth order was inversely associated with BMI, with first-borns having BMI that was 0.8% and 1.1% higher than second- and third-borns, respectively [5]. A New Zealand study on 50 middle-aged overweight men showed that first-borns had BMI that was 1.6 kg/m^2 greater than second-borns [13].

Apart from increased adiposity, there is mounting evidence that first-borns have an increased risk of adverse health outcomes later in life. These include increased risk of developing type 1 diabetes mellitus [14] and hypertension [15], with a study on 2,249 young adults in Brazil showing higher metabolic risk Z-scores in first-borns [6]. The New Zealand study on overweight middle-aged men also observed that first-borns had lower insulin sensitivity than second-borns [13], noting that insulin sensitivity is an independent predictor of metabolic and cardiovascular diseases [16]. Only the Italian study appears to have specifically examined health outcomes in adult women, observing that first-borns had an elevated metabolic risk compared to later-borns [10]. However, the study was carried out on a highly selected group (overweight and obese young women attending a weight loss clinic) who were not sibling pairs, so that their findings cannot be readily extrapolated to the general adult female population.

We observed a negligible effect of birth order on female adult stature, with first-borns just 1.2 mm taller than second-borns. There seems to be very little data on the association between birth order and height in women, and none from large studies. Previously, the study on Italian women observed no difference in stature between first- and later-borns [10], while among Indian women there was a weak correlation between birth order and stature (r=-0.20), but the magnitude of the effect was not quantified [11]. In contrast, data from large studies have consistently reported differences in men. The Brazilian study showed that first-borns were 8 mm taller than later-borns [6]. Jelenkovic et al. observed a decrease in height of 17 mm from birth order 1 to 6+ among one million Swedish men [5]. Another large Swedish study on 652,518 male conscripts observed that first-borns were 4, 7, and 8 mm taller than second-, third-, and fourth-borns, respectively [7]. There is a recognized sexual dimorphism associated with the long-term health consequences of early life events [8], and the limited evidence available suggests that the effects of birth order on adult stature may be sex-specific.

The triggers and mechanisms underpinning the observed effects of birth order are unknown. Ayyavoo et al. proposed that being first-born is associated with a degree of undernutrition *in utero* [17], based on the observed reductions in birth weight in first-borns compared to later-borns [2 4 18] (also observed in this study). It is possible that changes in placentation may be responsible for the observed differences in birth weight, with increased nutrient flow to later-born fetuses improving fetal growth in later pregnancies [17]. Importantly however, the observed differences between first- and later-borns cannot simply be attributed to reduced birth size, as previous findings [2 3 13] were observed even after adjustment for birth weight. Further, the timing and duration of any *in utero* insult that may affect first-borns is also yet to be described.

Note that we did not observe an association between sibship size and BMI. However, larger sibship size was associated with a reduction in height, a finding that is in accordance with numerous previous studies [19-21], which may be a result of the "resource dilution hypothesis" [19].

The magnitude of our observed associations between birth order and both BMI and stature in women differs to those from previous studies. Apart from obvious differences in sample size, previous studies focused on highly selected populations that limit wider applicability of their findings. In contrast, ours was not only the largest study of birth order effects on women, but was also the only one focusing specifically on sibling pairs to largely account for genetic factors and the early life environment. Lastly, it is most likely that the magnitude of observed effects would have been affected by the adoption of different confounding factors across studies.

Nonetheless, our study had limitations. Data on socioeconomic status of individual women were not available, and although socioeconomic background was accounted for due to the sibling comparisons, there might have been socioeconomic divergences between sisters over time. It is theoretically possible that other mediators not accounted for (such as dietary intake or physical activity levels) could in part explain the observed differences between first- and second-borns. Although data on such mediators were not available, our large sample size means that the effects of such variations between sisters were likely minimized. We have also selected women in a relatively narrow age range (i.e. entering pregnancy), to the exclusion of older women and those unable to conceive; given the natural tendency to increase weight with age, differences in BMI between first- and second-borns could be attenuated or accentuated later in life.. Lastly, we studied a relatively homogenous Nordic population that may preclude extrapolation of our findings to other ethnic groups or populations with greater levels of overweight/obesity.

In summary, our study corroborates other large studies on men, as we showed that first-born women have greater BMI and are more likely to be overweight or obese than their second-born sisters. The steady reduction in family size may be a contributing factor to the observed increase in adult BMI worldwide, not only among men but also women. Future large studies will need to clarify whether there is an associated increased in metabolic risk among first-born adult women.

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