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Associations of age at first birth and lifetime parity with weight and adiposity across midlife in women from Project Viva

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Abstract

Objective.—To evaluate the associations of age at first birth and parity with weight, waist circumference (WC), and body fat across midlife.

Methods.—We conducted a secondary data analysis of 735 participants from Project Viva who reported their age at first birth and lifetime parity at a midlife study visit. We measured weight, WC, and body fat up to four times after the participants' final birth and examined associations using linear mixed-effects regression models.

Results.—Participants mean (SD) age was 32.6 (4.9) years at enrollment, 30.4 (5.5) years at their first birth and they had 2.4 (0.9) lifetime births. In adjusted models, women who had their first birth <23 or ≥40 years, vs. 30–34, had a higher trajectory of weight, WC, and body fat after their final birth (i.e., mean differences in weight 8.38 kg [95%CI: 4.13, 12.63] for <23 and 6.54

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kg [95%CI: 0.64, 12.45] for ≥40 years). Women with four or more births, vs. two, had a higher trajectory of adiposity after accounting for covariates.

Conclusions.—Women who have a first birth before 23 or after 40 years and those with multiple births may benefit from more intensive monitoring for excess adiposity gain.

Keywords

Age at first birth; parous women; lifetime parity; weight; adiposity

Introduction

Although pregnancy is a risk factor for subsequent weight gain (1), less is known about how the total number and timing of births are associated with long-term weight and body composition. Understanding how these factors influence weight and adiposity gains could help to identify women at higher risk of obesity and metabolic conditions later in life.

Evidence on the association of age at first birth with changes in weight and adiposity is limited. The few studies conducted have shown that a younger age at first birth is associated with higher body mass index (BMI), waist circumference (WC), body fat, and risk of midlife overweight and obesity (2–5). As for parity, each additional live birth has been positively associated with BMI (2). However, some studies have not found associations between parity and adiposity (6). Others have observed contradictory results on the number of births associated with the highest risks for excess adiposity, with one or two births identified as high-risk groups (3,4). Most studies have focused on the association of reproductive exposures with BMI or adiposity assessed at a single time point (2–6), as opposed to repeated assessments over the lifespan, which may be more informative for assessing the risk of adverse health outcomes. Parity and age at first birth are interrelated as women who have a first birth at a young age may have more births throughout their life (7,8). Therefore, an additional limitation of most studies is that they have not considered the independent effects of the timing of the first birth and parity (2,3,5,6), which is fundamental to understanding how these characteristics affect weight and adiposity. Therefore, we conducted a prospective study to evaluate the associations of age at first birth and lifetime parity with weight, WC, and body fat using repeated assessments collected up to 20 years after the participant's final birth.

Methods

Study population and design

We conducted a secondary data analysis of participants from Project Viva, an ongoing prospective cohort of women recruited during pregnancy (1999–2002) from Atrius Harvard Vanguard Medical Associates (hereafter referred to as the index pregnancy). Inclusion criteria included singleton pregnancy, <22 weeks of gestation (mean [SD] 11 [3] weeks), ability to answer questions in English, and planning to stay in the study area until delivery. Fifty-two percent of the participants were parous at study enrollment. Details on recruitment and eligibility have been described elsewhere (9). Of the 2100 women enrolled in Project Viva, we restricted this analysis to 752 who completed a reproductive history questionnaire during the "midlife" study visit at a mean (SD) of 18 (0.7) years after enrollment. We excluded 17 women without any anthropometric outcome data during follow-up for an analytical sample of 735 women (Figure S1). Women included (n=735) in the analysis were older (32.6 vs. 31.4 years) and more likely to be college graduates (75.6 vs. 58.5%), married/cohabiting (93.3 vs. 90.2%), and to have a household income >$70,000/year (65.6 vs. 58.0%) at enrollment than those excluded (n=1,365). Age at first birth and parity were not related to participation during follow-up. Similarly, BMI preceding the index pregnancy, weight, WC, and body fat across follow-up visits did not differ between women included and excluded from analysis.

We conducted the analyses for age at first birth in the total analytic sample (n=735). Because all relevant potential confounders assessed before the first pregnancy, essential to minimizing the possibility of collider-stratification bias (10), were only available among nulliparous women at enrollment, we restricted the analyses for parity to the 354 women in this subset. Briefly, collider-stratification bias results from conditioning on factors that are on the pathway between exposure and outcome, and share an unmeasured common cause with the outcome (10).

All participants provided written informed consent at enrollment and each study visit. The institutional review board of Harvard Pilgrim Health Care approved all study protocols.

Exposures: Age at first birth and lifetime parity

Women provided data on each of their lifetime pregnancies in a reproductive history questionnaire administered during the midlife visit. To define our exposures, we considered only pregnancies lasting ≥20 weeks and pregnancies that were not tubal, ectopic, or induced abortions regardless of length; we considered multiple gestations as one pregnancy. We defined age at first birth as the difference between the year when the first pregnancy ended and the participant's date of birth and lifetime parity as the total number of self-reported births. We categorized age at first birth as <23, 23–29, 30–34, 35–39, and ≥40 years, and parity as one, two, three, and four or more births. We selected the lowest category of age at first birth as <23 based on the age distribution of our population and because this threshold coincides with the typical age at college graduation in the United States (US) (11), which is associated with better health outcomes in women (12,13). We defined the highest age categories using cut-offs that align with those used to report pregnancy rates and outcomes by public health agencies (14). For parity, we selected two births as the reference group, given that it is the most common parity in the US (15).

Outcomes: Weight and adiposity

The outcomes were repeated measures of weight, WC, and total body fat (kg and %) collected at study visits conducted approximately 3, 7, 12, and 18 years after enrollment, except for body fat that was not measured at 3 years. We considered only measurements collected at least one year after the woman's final lifetime birth (range 1–20 years) to avoid extraneous bias due to the acute effect of recent pregnancies on adiposity and because we were interested in the longer-term impact of reproductive exposures on anthropometric outcomes. Additional details on outcome assessment are provided in Appendix S1.

Covariates

The covariates included race and ethnicity (White, Black, other) and characteristics capturing socioeconomic status (SES) before the participant's first birth, such as maternal and paternal education (graduated college, yes/no) and whether the participants had ever received public assistance, welfare, or lacked basic necessities (such as food, rent, or medical care) before they were 18 years old (yes/no), reported at the first study visit (index pregnancy) (Figure S2). We also included age at menarche (<12 years, 12–14, ≥15 years), as earlier menarche is associated with a younger age at first birth and long-term adiposity (16–18). As metrics of baseline adiposity, we considered pre-pregnancy BMI (kg/m^2) calculated from self-reported pre-pregnancy weight and height at the index pregnancy and perceived weight status when the participant was ten years old (underweight, average, or overweight), self-reported at baseline.

Statistical analysis

We used linear mixed-effects regression models (19) to examine the prospective associations of age at first birth (<23, 23–29, 30–34 [reference], 35–39, and ≥40 years) and parity (one, two [reference], three, four, or more births) with longitudinal assessments of weight (kg), WC (cm), and body fat (kg and %) after the final birth (1–20 years). We fitted separate models for each exposure and included a random intercept and slope with an unstructured correlation matrix to account for repeated measures in the same individual.

We considered the covariates depicted in figure S2 as potential confounders, prioritizing those assessed before each exposure. The primary model for age at first birth included years since the final birth, and several confounders before all pregnancies: race and ethnicity, maternal and paternal education, public assistance <18 years, age at menarche, and recalled weight status at ten years. In a secondary model, we adjusted for pre-pregnancy BMI (index pregnancy) as a proxy for baseline weight and adiposity, acknowledging that, for the 50% of women who were parous at enrollment, this was a post-exposure metric likely affected by prior pregnancies. For parity, our primary model accounted for the same covariates and additionally adjusted for age at first birth and pre-pregnancy BMI. Pre-pregnancy BMI was a pre-exposure metric in the subset of women included in this analysis (i.e., n=354 women non-parous at enrollment as previously described). We had information available on adulthood SES at enrollment (i.e., education and household income); however, because these characteristics are likely affected by having a birth at a younger age (20,21), we did not adjust for them in our main analysis. Nevertheless, accounting for education and income in an analysis restricted to nulliparous women at enrollment yielded consistent results (data not shown). Outcome trajectories were not different by exposure status, i.e., $P>0.05$ for the interaction of either exposure with time in years since the final birth; therefore, model estimates reflect the mean differences (95% confidence interval [CI]) for the average adiposity trajectory across follow-up with respect to categories of age at first birth or parity.

Sensitivity analyses

We conducted sensitivity analyses to assess the robustness of our findings. When age at first birth was the exposure, we adjusted the primary model for parity; second, we restricted the analysis to women who had two births; and third, we limited the analysis to women whose final birth was the index pregnancy.

When parity was the exposure, we conducted a sensitivity analysis restricted to women who had their first birth from 30 to 39 years, accounting for the same covariates as in the main analysis, including age at first birth. In a subsequent analysis, we adjusted the primary model for the average inter-pregnancy interval defined as the length of time (months) between each child's birth year minus 280 days for a term and 259 days for a preterm infant (22). We excluded women with one birth as they could not contribute to this analysis.

Next, we restricted the analysis for age at first birth to nulliparous women at enrollment. For age at first birth and parity, we conducted two additional sensitivity analyses adjusting the primary model for height or menopausal status reported at the midlife visit (yes vs. no, postmenopausal [43%]).

We imputed missing covariates via chained equation multiple imputation (23). We generated 50 imputed data sets using an imputation model that included the studied exposures, outcomes, and covariates. Covariates with the highest proportion of missing values included public assistance, income, weight status at ten years and age at menarche (5–8%). We combined and analyzed the imputed data sets using MI ESTIMATE in Stata 16. We conducted all the analyses in Stata 16 (StataCorp L.P., College Station, TX).

Results

Participants in the total sample (n=735) had a mean age of 32.6 (4.9) years at enrollment, 30.4 (5.5) years at their first birth, and had on average 2.4 births. Most women were White (69%), married (93.3%), college-educated (75.6%), and high income (65.6%) (Table 1). Around 45% had college-educated parents, and 8.8% had received public assistance. The subset of women (n=354) included in the parity analysis had similar characteristics. Age at first birth and parity were inversely related to each other. In addition, women who had their first birth before 23 years were less likely to be White, have college-educated parents, and more likely to have received public assistance. Baseline characteristics across parity categories were homogeneous (Table 1).

Age at first birth and adiposity through midlife

In the primary model (Figure 1), women who had their first birth before 23 years or after 40 years, compared to 30–34 years, had a higher trajectory of all adiposity measures. The adjusted mean differences for women with a first birth before 23 years were 8.38 kg (95% CI: 4.13, 12.63) for weight, 6.8 cm (95% CI: 3.3, 10.3) for WC, and 6.99 kg (95% CI: 3.72, 10.26) for fat mass, and 4.6% (95% CI: 2.4, 6.7) for body fat percentage. The corresponding figures for women whose first birth was after 40 years were 6.54 kg (95% CI: 0.64, 12.45) for weight, 5.5 cm (95% CI: 0.6, 10.4) for WC, 5.61 kg (95% CI: 1.02, 10.20) for fat mass, and 4.8% (95% CI: 1.7, 7.8) for body fat percentage. These associations were attenuated after accounting for pre-pregnancy BMI in a secondary model, but most remained significant (Table 2).

Lifetime parity and adiposity through midlife

The extreme categories of parity were associated with the measures of adiposity in the primary model (Figure 2). Compared to women with two births, those with four or more births had a higher trajectory of weight, WC, fat mass, and body fat percentage across follow-up with mean adjusted differences of 6.65 kg (95% CI: 1.93, 11.37), 6.3 cm (95% CI: 2.3, 10.2), 4.01 kg (95% CI: 0.58, 7.44) and 2.7% (95% CI: 0.1, 5.2), respectively. The corresponding estimates for women with one birth were 2.53 kg (95% CI: −0.27, 5.34) for weight, 1.2 (95% CI: −1.2, 3.5) for WC, 2.62 kg (95% CI: 0.43, 4.80) for fat mass, and 1.6% (95% CI 0.0, 3.2) for body fat percentage.

Sensitivity analyses

Since earlier age at first birth is often associated with higher lifetime parity and both characteristics affect weight and body composition, we conducted sensitivity analyses to disentangle their association. To independently assess age at first birth as the exposure of interest, we adjusted the primary model for parity (Table S1). Next, we conducted an analysis restricted to the 363 women who had exactly two births (Table S2) to maintain parity fixed; and conducted a separate analysis restricted to the 374 women whose final birth was the index pregnancy, since any additional weight gain in this group could not be attributed to subsequent pregnancies (Table S3). In all these sensitivity analyses, consistent with the main analysis, women who had their first birth before 23 years or after 40 years had a higher weight, WC, and body fat trajectory across follow-up compared to the reference group. Of note, in the analysis restricted to women with two births, the differences in measures of adiposity for women with a first birth after 40 years were not statistically significant. However, this group comprised a small sample (n=7).

To separate the effect of age at first birth from the association of parity with adiposity, we restricted the analysis to 227 women who had their first birth between 30–39 years to limit the age range at first birth when investigating parity. Women who had four or more births had a higher trajectory of adiposity than women who had two births; having one birth was no longer associated with greater adiposity (Table S4). Next, we accounted for the average inter-pregnancy interval in months and observed consistent results for the groups included in this analysis (Table S5). To evaluate the potential bias caused by adjusting for pre-pregnancy BMI (index pregnancy) in the secondary model for age at first birth, we restricted the analysis to 354 nulliparous women at enrollment, in which pre-pregnancy BMI was a baseline metric and observed consistent results with the main analysis (Table S6). We then adjusted the primary models for age at first birth and parity for height, given that it affects predisposition toward weight gain and to account for the physiological implications of weight and adiposity gains due to differences in stature. The results for age at first birth (Table S7) and parity (Table S8) were consistent with the main analysis, although having one birth was no longer associated with higher gains in adiposity in these models. Last, we adjusted the models for menopausal status, given that women tend to gain weight and body fat after menopause (24). The results for both exposures (Tables S9 and S10) were consistent with the main analysis.

Discussion

We examined the associations of age at first birth and lifetime parity with adiposity over a 20-year follow-up period. Women who had their first birth before 23 years or after 40 years had a higher trajectory of weight, WC, and body fat during up to two decades of follow-up. Women who had four or more births also had a higher trajectory of weight and adiposity. Our findings also suggest that, despite the interrelation between age at first birth and parity, each of these reproductive factors might contribute independently to changes in weight and adiposity that persist years beyond the end of a woman's reproductive life stage.

Our results for age at first birth are consistent with those of Patchen et al., who analyzed data from the US Panel Study of Income Dynamics. The authors restricted the study sample to 146 women who were non-parous at baseline in 1999 (mean age of 18 years) and experienced their first birth during the 12-year follow-up. Women who were 21 years or younger, or 22 to 29 years of age at their first birth, had a higher trajectory of BMI compared to those who had their first birth after 30 years (≤21 years: β 5.02, 95% CI: 0.65, 9.40; 22–29 years: β 4.62, 95% CI 0.31, 8.93) (5). Our findings are consistent with the results of different studies showing inverse associations of age at first birth with BMI, WC, and body fat assessed at a single time point around midlife (2,3). However, to our knowledge, our study is the first to identify associations of age at first birth with longitudinal trajectories of weight and adiposity up two decades after the final birth and among women with first births after 40 years. Although it needs to be confirmed in future studies, this latter finding is particularly relevant as the rates of first births to older women continue to increase in the US (25).

In agreement with our findings for parity, in an analysis of Swedish women with one outcome time point, those with four or five or more live births, compared to two, had higher odds of obesity at midlife with stronger associations for the latter category (four births: OR 1.2, 95% CI: 1.0, 1.5; five or more births: 1.6 95% CI: 1.3, 2.0) (26). Although not directly comparable with our study, we know only one prospective study assessing changes in BMI after the reproductive years. Zoet et al. studied Dutch women aged 52 to 57 years and found that those with two or more children, as a proxy of births, had a greater gain in BMI across six years of follow-up compared to women with one or no children (27). They did not separately report results for women with more than three children. We also found a suggestive association of a higher trajectory of adiposity among women with one (vs. two) births, but it was weak and not replicated in sensitivity analyses.

The associations of younger age at first birth with long-term adiposity trajectories might theoretically be explained by multiparity, as women who have a first birth at a young age are often more likely to have more children throughout their life (7,8). Multiparity might be associated with changes in weight and adiposity via repeated cycles of excessive gestational weight gain and postpartum weight retention (1,28). However, in our study, the results from sensitivity analyses do not support this mechanism. Rather, our results suggest that associations between early age at childbirth and adiposity later in life might be independent of parity. One potential mechanism is related to education and other socioeconomic consequences of early childbirth. For instance, teen pregnancies tend to be associated with lower subsequent educational attainment (20,21), a greater likelihood of unemployment, and having a low income during adulthood (20), which are related to a poor lifestyle and greater weight gain in adults (29,30). Therefore, our findings may reflect downstream social and economic factors that result from having children earlier in life and increase the risk of weight gain later in life. Alternatively, our findings may transpire from upstream social and economic factors associated with early childbirth and obesity (29–31). However, our results were robust to adjustment for proxies of such characteristics (i.e., parental education, public assistance), suggesting confounding by upstream socioeconomic factors is not driving our findings.

The associations between older age at first birth and adiposity trajectories might, to some extent, be related to existing obesity before the first pregnancy, given that obesity is more prevalent as women age (32). Also, obesity could be associated with delayed childbirth through reproductive impairments manifested by a longer time to conceive and a higher risk of early pregnancy loss (33). This mechanism is supported by the slight attenuation in the estimates when we included pre-pregnancy BMI in the models. These results must be interpreted cautiously due to the small sample of women in this category. Additional studies are needed to confirm our findings and understand their underlying mechanisms.

Our results must be interpreted considering the strengths and limitations of the study. Most prior studies have used a single assessment of BMI, and less commonly WC and body fat, around midlife. It is a strength of our study that we used repeated objective assessments of weight, WC, and body fat up to 20 years after the participants' final pregnancies and spanning into midlife. This approach allowed us to explore the long-term effect of age at first birth and parity and minimize the acute impact of pregnancies on subsequent weight and adiposity. The availability of important covariates is also a strength.

Our study has some limitations. First, we had exposure and outcome information for only 35% of women initially enrolled in the study, and there were sociodemographic differences between those included and excluded. While there was no evidence that age at first birth, baseline parity, and outcomes assessed during follow-up influenced selection into the analytic sample, women included were of higher SES than those not included (i.e., higher educational attainment and household income), and there may be additional, unmeasured confounders that also differ between included and excluded participants. Therefore, we cannot rule out the possibility of selection bias. Second, reproductive information was self-reported 18 years after enrollment, which might lead to misclassification of exposure status; however, ample evidence suggests that maternal recall of pregnancy-related events is reliable (34,35). Third, our sample size was modest, and we did not have enough women with births ≤18 years (n=27) to analyze them in a separate category and conduct the appropriate sensitivity analyses. Despite this, considering age at first birth before 23 years as the lowest category is informative as this period represents the average age at college graduation in the US and an important milestone associated with women's long-term health (12,13). Fourth, we did not have information on BMI before the first pregnancy for all women. Instead, our secondary model for age at first birth used pre-pregnancy BMI (index pregnancy). Pre-pregnancy BMI might be affected by pregnancies before study enrollment, and adjusting for it might have led to collider-stratification bias (10). However, we observed consistent results in a sensitivity analysis restricted to non-parous women at enrollment. Fifth, we did not account for education and household income because data on these variables were collected at study enrollment and, therefore, could be affected by the timing of the first birth. Instead, we accounted for the education of the woman's parents and receipt of public assistance <18 years, the only upstream SES characteristics available in our study. Accordingly, we acknowledge the possibility of residual confounding for social and economic factors associated with the timing of the first birth (31). Also, we cannot rule out residual confounding for dietary patterns and physical activity before the first birth. Sixth, our results might only be generalizable to women of a similar sociodemographic background as in this study. Lastly, for the analyses on parity, we did not have a non-parous comparison group; therefore, our findings might be interpreted as the difference in weight and adiposity trajectories across categories of increasing parity.

Conclusions

Based on results from this study, women who have a first birth before 23 or after 40 years and those with multiple births might represent high-risk groups for developing adverse weight and adiposity trajectories and may benefit from more intensive monitoring for the development of excess weight gain. These findings emphasize the importance of supporting women to mitigate the social and economic consequences of childbirth, particularly when it occurs at a young age. Furthermore, our findings reiterate the need to support women to reach their pre-gestational weight after each pregnancy and ultimately maintain a healthy weight. Future studies should aim to establish the ideal interventions and monitoring patterns needed to minimize the impact of childbirth.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is already known about this subject?

- A limited number of studies have suggested associations of the timing of the first birth, as well as the total number of births across a woman's lifetime, with weight and adiposity later in life, typically at midlife.
- None of these studies have evaluated weight and adiposity at multiple time points in relation to those reproductive characteristics.

What are the new findings in your manuscript?

- Women who had their first birth at a younger (<23 years) or older age (≥40 years) and those who had four or more lifetime births had a higher trajectory of weight, waist circumference, and body fat up to 20 years after their final birth.
- The timing of the first birth and parity might contribute independently to changes in weight and adiposity that persist years beyond the end of a woman's reproductive stage.

How might your results change the direction of research or the focus of clinical practice?

- Our findings emphasize the need to support women to mitigate the biological and social effects of childbirth, particularly when it occurs at the extremes of the reproductive stage and repeatedly during their life course.
- Future studies should aim to establish the ideal interventions and monitoring patterns needed to minimize the impact of childbirth.

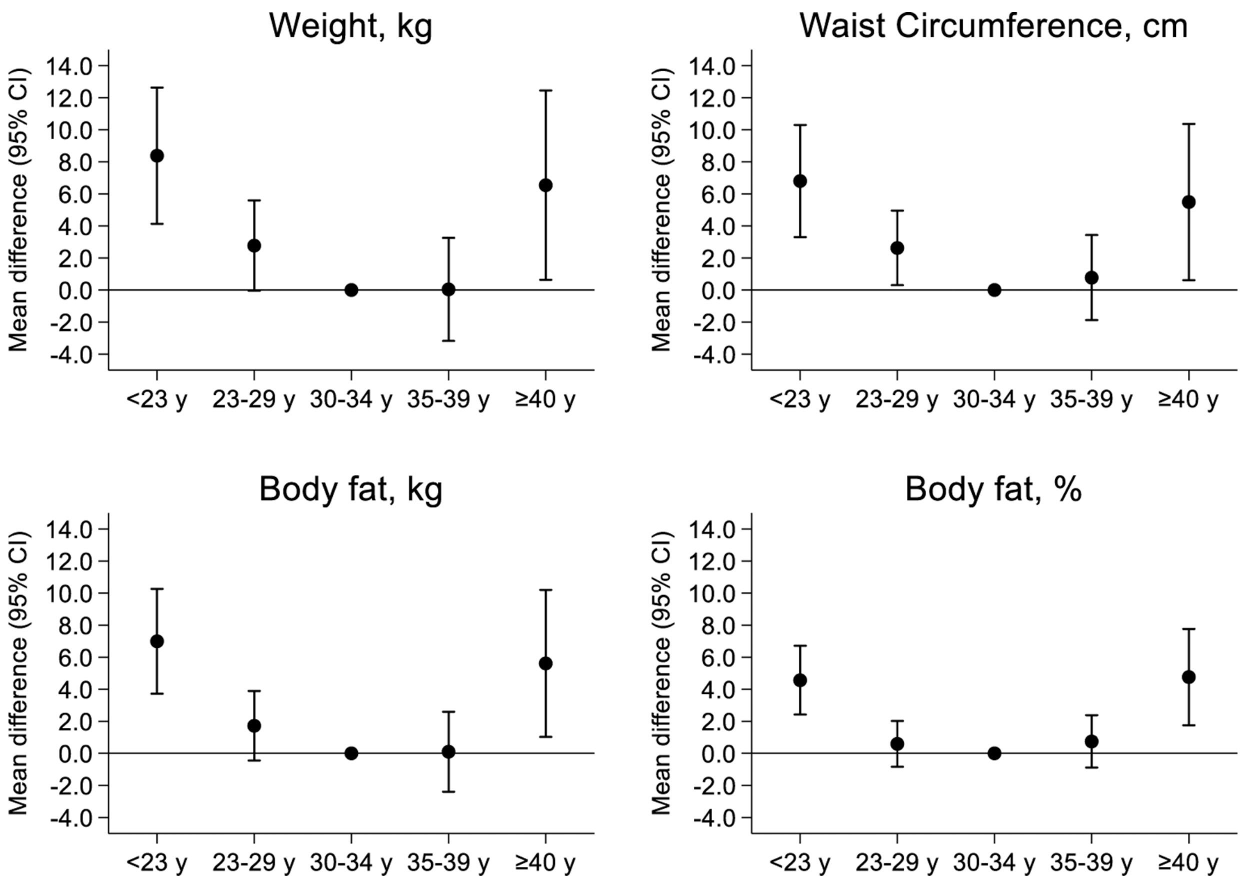

Figure 1. Associations of age at first birth with weight and adiposity trajectories from 1 to 20 years after the final birth among 735 women from Project Viva.

Estimates represent mean difference (95% CI) from mixed-effects regression models where the outcome was repeated assessments of weight and adiposity. The exposure was age at first birth (<23 , 23–29, 30–34 [ref], 35–39, and ≥40 years). Model adjusted for years since the final birth, race and ethnicity (White, Black, other), maternal and paternal college education (yes/no), ever received public assistance <18 years (yes/no), age at menarche (<12 years, 12–14 years, ≥15 years), and weight status at ten years of age (underweight, average, overweight).

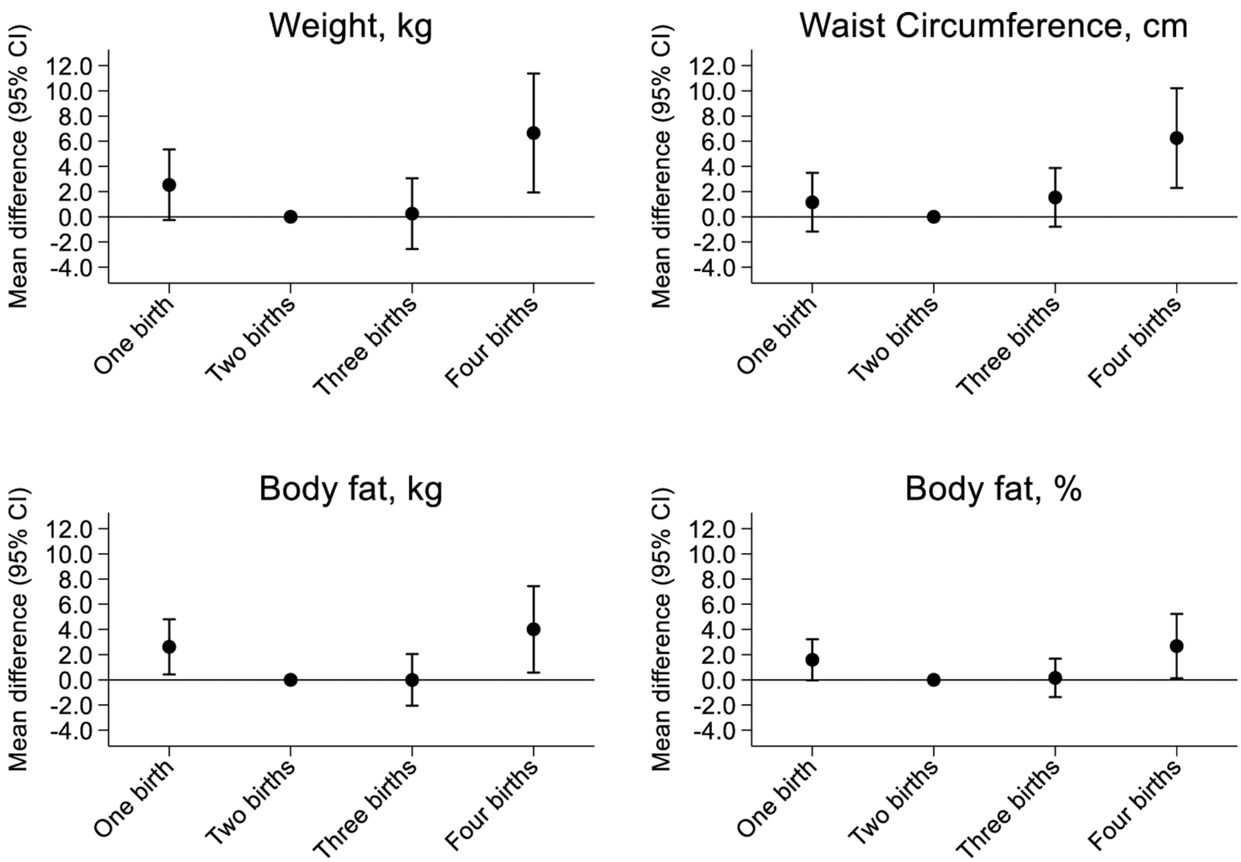

Figure 2. Associations of lifetime parity with weight and adiposity trajectories from 1 to 20 years after the final birth among 354 women from Project Viva.

Estimates represent mean difference (95% CI) from mixed-effects regression models where the outcome was repeated assessments of weight and adiposity. The exposure was lifetime parity (One, two [ref], three, and ≥four births). Model adjusted for years since the final birth, race and ethnicity (White, Black, other), maternal and paternal college education (yes/no), ever received public assistance <18 years (yes/no), age at menarche (<12 years, 12–14 years, ≥15 years), weight status at ten years of age (underweight, average, overweight), age at first birth (years) and body mass index prior to the index pregnancy (kg/m^2) (Index refers to the pregnancy at participant's enrollment into Project Viva).

Table 1.

Distributions of characteristics by age at first birth and lifetime parity in women participating in Project Viva[a]

	Age at first birth						Lifetime parity				
	All women (n=735)	**<23 y (n=77, 10.5%)**	**23–29 y (n=187, 25.4%)**	**30–34 y (n=323, 44%)**	**35–39 y (n=120, 16.3%)**	**≥40 y (n=28, 3.8%)**	**All women (n=354)**	**One birth (n=81, 22.9%)**	**Two births (n=182, 51.4%)**	**Three births (n=71, 20.1%)**	**≥four births (n=20, 5.6%)**
Characteristics at enrollment	**Mean (SD)**						**Mean (SD)**				
Age, years	32.6 (4.9)	26.4 (6.6)	29.9 (3.8)	33.2 (2.6)	37.4 (2.1)	40.7 (1.4)	31.2 (5.2)	34.5 (5.6)	31.2 (4.5)	28.5 (4.6)	28 (4.3)
Pre-pregnancy BMI, kg/m^2[b]	24.7 (5.1)	27 (6.0)	24.9 (5.8)	24.1 (4.5)	24.1 (4.6)	25.5 (4.9)	24.3 (4.9)	24.7 (5.3)	24.4 (5.0)	24 (4.3)	23.9 (3.9)
	N (%)						**N (%)**				
Race and ethnicity											
White	506 (69.0)	15 (19.5)	116 (62.0)	253 (78.6)	99 (83.2)	23 (82.1)	255 (72.2)	51 (63.0)	143 (79.0)	48 (67.6)	13 (65.0)
Black	105 (14.3)	34 (44.2)	39 (20.9)	21 (6.5)	9 (7.6)	2 (7.1)	43 (12.2)	17 (21.0)	16 (8.8)	8 (11.3)	2 (10.0)
Other	122 (16.6)	28 (36.4)	32 (17.1)	48 (14.9)	11 (9.2)	3 (10.7)	55 (15.6)	13 (16.0)	22 (12.2)	15 (21.1)	5 (25.0)
Mother graduated college	296 (40.3)	14 (18.2)	67 (35.8)	149 (46.1)	53 (44.2)	13 (46.4)	157 (44.4)	29 (35.8)	81 (44.5)	39 (54.9)	8 (40.0)
Father graduated college	355 (48.3)	14 (18.2)	75 (40.1)	175 (54.2)	71 (59.2)	20 (71.4)	176 (49.7)	38 (46.9)	93 (51.1)	35 (49.3)	10 (50.0)
Ever received public assistance <18 years of age	60 (8.8)	15 (25.0)	19 (11.0)	23 (7.6)	3 (2.6)	0 (0)	25 (7.6)	6 (8.0)	14 (8.1)	3 (4.8)	2 (10.0)
College education	554 (75.6)	8 (10.4)	131 (70.1)	281 (87.3)	108 (90.8)	26 (92.9)	290 (82.2)	65 (80.2)	153 (84.5)	58 (81.7)	14 (70.0)
Married/cohabiting	683 (93.3)	53 (68.8)	168 (90.3)	317 (98.4)	118 (99.2)	27 (96.4)	323 (91.8)	75 (92.6)	167 (92.8)	64 (90.1)	17 (85.0)
Household income>$70,000	442 (65.6)	9 (17.0)	89 (53.6)	232 (74.8)	97 (82.9)	15 (53.6)	231 (69.8)	49 (61.3)	130 (75.6)	43 (70.5)	9 (50.0)
Recalled weight status at age ten years											
Underweight	112 (16.3)	7 (11.3)	34 (19.4)	51 (16.7)	15 (12.8)	5 (18.5)	55 (16.5)	15 (19.7)	30 (17.4)	6 (9.2)	4 (20.0)
Average	498 (72.6)	45 (72.6)	128 (73.1)	221 (72.5)	88 (75.2)	16 (59.3)	239 (71.8)	47 (61.8)	123 (71,5)	54 (83.1)	15 (75.0)
Overweight	76 (11.1)	10 (16.1)	13 (7.4)	33 (10.8)	14 (12.0)	6 (22.2)	39 (11.7)	14 (18.4)	19 (11.0)	5 (7.7)	1 (5.0)
Age at menarche											

	Age at first birth						Lifetime parity				
	All women (n=735)	**<23 y (n=77, 10.5%)**	**23–29 y (n=187, 25.4%)**	**30–34 y (n=323, 44%)**	**35–39 y (n=120, 16.3%)**	**≥40 y (n=28, 3.8%)**	**All women (n=354)**	**One birth (n=81, 22.9%)**	**Two births (n=182, 51.4%)**	**Three births (n=71, 20.1%)**	**≥four births (n=20, 5.6%)**
<12 years	115 (16.5)	22 (30.1)	30 (17.0)	45 (14.5)	15 (13.4)	3 (12.5)	56 (16.8)	11 (14.3)	24 (14.2)	14 (20.6)	7 (36.8)
12–14 years	510 (73.3)	41 (56.2)	127 (72.2)	241 (77.5)	84 (75.0)	17 (70.8)	249 (74.8)	59 (76.6)	128 (75.7)	50 (73.5)	12 (63.2)
≥15 years	71 (10.2)	10 (13.7)	19 (10.8)	25 (8.0)	13 (11.6)	4 (16.7)	28 (8.4)	7 (9.1)	17 (10.1)	4 (5.9)	0 (0)
Non-parous	354 (48.2)	23 (29.9)	79 (42.2)	160 (49.5)	67 (55.8)	25 (89.3)	354 (100)	-	-	-	-
Reproductive characteristics	**Mean (SD)**						**Mean (SD)**				
Age at first birth, years[c]	30.4 (5.5)	19.3 (1.9)	27 (2.0)	31.9 (1.3)	36.6 (1.3)	41.1 (1.3)	31.7 (5.2)	35.0 (5.6)	31.7 (4.5)	29 (4.6)	27.8 (4.6)
Lifetime parity[c]	2.4 (0.9)	2.9 (1.0)	2.7 (1.0)	2.4 (0.8)	1.9 (0.6)	1.3 (0.4)	2.1 (0.9)	1 (0)	2 (0)	3 (0)	4.6 (0.8)

BMI: body mass index.

[a] The study sample includes 735 women for age at first birth and 354 women for lifetime parity (non-parous at enrollment). The sample for each individual characteristic may not add to 735 or 354 due to missing covariate data.

[b] Body mass index before the index pregnancy (Index refers to the pregnancy at participant's enrollment into Project Viva).

[c] Age at first birth, range: 16–45 years; parity, range:1–8 births.

Table 2.

Associations of age at first birth with weight and adiposity trajectories from 1 to 20 years after the final birth among 735 women from Project Viva with secondary adjustment for pre-pregnancy body mass index[a]

	Adjusted mean difference (95% CI)
	Model
	Weight, kg
<23 y (n=77)	4.47 (1.87, 7.07)
23–29 y (n=187)	0.80 (−0.93, 2.53)
30–34 y (n=323)	Reference
35–39 y (n=120)	−0.24 (−2.20, 1.72)
≥40 y (n=28)	3.25 (−0.35, 6.86)
	Waist circumference, cm
<23 y (n=77)	3.57 (1.34, 5.80)
23–29 y (n=187)	0.99 (−0.50, 2.47)
30–34 y (n=323)	Reference
35–39 y (n=120)	0.57 (−1.11, 2.25)
≥40 y (n=28)	2.99 (−0.10, 6.08)
	Body fat, kg
<23 y (n=76)	3.96 (1.96, 5.96)
23–29 y (n=186)	0.33 (−1.00, 1.65)
30–34 y (n=321)	Reference
35–39 y (n=118)	0.11 (−1.41, 1.63)
≥40 y (n=28)	2.91 (0.06, 5.75)
	Body fat, %
<23 y (n=76)	2.69 (1.18, 4.20)
23–29 y (n=186)	−0.16 (−1.17, 0.84)
30–34 y (n=321)	Reference
35–39 y (n=118)	0.74 (−0.41, 1.89)
≥40 y (n=28)	3.19 (1.04, 5.34)

[a]Estimates represent mean difference (95% CI) from mixed-effects regression models where the outcomes were repeated assessments of weight and adiposity. The exposure was age at first birth (<23, 23–29, 30–34 [ref], 35–39, and ≥40 years).

Model: adjusted for years since the final birth, race and ethnicity (White, Black, other), maternal and paternal college education (yes/no), ever received public assistance <18 years (yes/no), age at menarche (<12 years, 12–14 years, ≥15 years), weight status at ten years of age (underweight, average, overweight) and body mass index prior to the index pregnancy (kg/m^2) (Index refers to the pregnancy at participant's enrollment into Project Viva).