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Original Article

Body Mass Index at Age 20 and Subsequent Childbearing: The Adventist Health Study-2

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Abstract

Background: Some epidemiological, clinical, and laboratory studies suggest that underweight and obesity impact fertility.
Methods: This is cross-sectional study of 33,159 North American Adventist women, who were nulliparous at age 20 years and who, as a group, have a healthy lifestyle. Logistic regression analysis was used to assess how body mass index (BMI, kg/m^2) at age 20 was related to never becoming pregnant, never giving birth to a living child, or not giving birth to a second or third child.
Results: A total of 4954 (15%) of the women reported never becoming pregnant (nulligravidity) and 7461 (23%) women remained nulliparous. Underweight ($BMI < 18.5\,kg/m^2$) at age 20 was associated with approximately 13% increased risk of nulligravidity or nulliparity. Women with $BMI \geq 32.5\,kg/m^2$ when aged 20 had 2.5 (95% CI: 2.0, 3.1) times increased odds of nulliparity compared to women with BMI 20–24.9 kg/m^2. Increased risk was found for all groups of overweight women ($BMI \geq 25\,kg/m^2$). However, if the women gave birth to one live child after age 20, $BMI \geq 32.5\,kg/m^2$ at age 20 had less impact (OR 1.6 [95% CI: 1.2, 2.2]) on the likelihood of not delivering a second child. In women who delivered two living children, obesity at age 20 had no bearing on the odds of having a third child.
Conclusions: Obesity and, to a lesser extent, underweight at age 20 increases the nulliparity rate. The results underscore the importance of a healthy weight in young women.

Introduction

Childbearing is important in the life of most women, and it is thus important to identify factors that may influence the ability to give birth to children. Results from clinical and laboratory studies support the hypothesis that obesity influences fertility both in men and women.[1] The impact of obesity has been the topic of more research than the impact of underweight, but there is also evidence that underweight may reduce fertility.[2,3]

Jokela et al.[3] found an inverted J-shaped relationship between adolescent body mass index (BMI) and parity in Finnish women. Furthermore, the probability of having a first, second, or third child by the age of 39 was lower in underweight and obese women than in women with normal BMI. The relationship with parity was weakened when adjusted for ever having lived with a partner, but was still present in women who had ever been married or lived with a partner. Relationships between skinfold thickness and parity were in the same direction as those found for BMI, although not statistically significant.

A U.S. study with a similar design found that obesity was statistically significantly associated with lower probability of giving birth to a first and third (but not second and fourth) child after adjustment for marital status. No significant relationship was found with underweight, although the point estimate suggested a reduced probability of childbearing.[4]

In a community-based U.S. study (the Study of Women's Health Across the Nation [SWAN] cohort) of 3154 women aged 42–52,[5] obesity during high school conferred an increased risk of both nulliparity and nulligravidity. The relationship with obesity was found in a number of strata of the population. Underweight was, however, associated with borderline significance with a reduced prevalence of nulliparity. Relationships between high school BMI and the likelihood of giving birth to a second or third child were not investigated.

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There is a paucity of epidemiological studies of relationships between under- and overweight and parity conducted within large diverse populations. In particular, there is need for studies that include information about possible confounders beyond marital status, race, education, and residence. The impact of obesity may depend on other lifestyle factors such as diet, physical activity, and smoking. An obvious example is smoking because smokers have lower fertility[6] and lower weight[7] than nonsmokers.

Studies with a large sample size are necessary in order to assess the importance of conditions with relatively low prevalence, such as severe obesity. The analysis based on the SWAN cohort[5] included only 97 obese women (BMI $\geq 30\,kg/m^2$).

Any relationship between BMI (particularly obesity) and childbearing should have an important impact on public health because the prevalence of obesity has increased worldwide,[8] although less perhaps in the United States during the most recent years.[9,10] Prepregnancy prevalences of underweight and obesity in the United States were estimated to be 5% and 19%, respectively, in 2004–2005 [11]

We recently reported relationships between the BMI of young women, as recalled when they have ended their reproductive period, and their likelihood of reporting miscarriages, irregular periods, and problems becoming pregnant.[12] However, the essential characteristic of female reproduction is the ability to give birth to a live child. The aim of this report was therefore to describe how underweight and overweight in young women influences their likelihood of successfully producing children. In a group of women who were nulliparous at age 20, we investigated the relationships between BMI at age 20 and the subsequent probability of never becoming pregnant or never giving birth to a live child, or after a successful first birth never giving birth to a second or third child. Based on previous laboratory, clinical and epidemiological studies,[1–5] we hypothesized that both under- and overweight would reduce the likelihood of giving birth to a live child.

More than 33,000 American Adventist women were included in the analyses. Thus, investigation of effects of both underweight (BMI $< 18.5\,kg/m^2$) and obesity (both BMI 30–32.5 kg/m^2 and $\geq 32.5\,kg/m^2$) could be performed.

Material and Methods

Subjects

Adventist church members living in the United States and Canada, aged 30 years and older, were enrolled in the Adventist Health Study-2 (AHS-2) between February 2002 to December 2007.[13] The Adventist Health Study research protocols have been approved by the Loma Linda University Institutional Review Board.

More than 96,000 participants returned a lifestyle questionnaire, about 25,500 were black Adventists and 62,500 were women. About 90% of the nonblack subjects were non-Hispanic white. The Adventist church encourages a healthy life style with no smoking and alcohol consumption and advises members to follow a vegetarian diet, although only about half do so.

Questionnaire information

The self-administered questionnaire included, among other topics, sections for medical history, marital status, ethnic group, and lifestyle variables such as smoking, the use of alcohol and caffeine-containing beverages.[12] Ever users of alcohol were identified as subjects who answered "yes" to the question "Have you ever used alcoholic beverages even if only occasionally?" Ever smokers answered affirmatively to the question "Have you ever smoked regularly?"

There were also questions about current weight and height as well as weight when aged 20. BMI was computed as weight in kilograms divided by the square of height in meters (kg/m^2). Most variables included in the present analyses were derived from the female history section, which included information concerning menstruation and difficulties in becoming pregnant, whether the women had ever been pregnant and the outcome of the pregnancies (miscarriages/stillbirths, ectopic pregnancies, elective abortion and live births), age at each delivery of a live child, and the use of oral contraceptives.

Women were considered to have experienced menstrual irregularities if they answered "yes" to the question "Have your periods ever had much reduced flow, become irregular or stopped completely for at least six months? Do not count during or after menopause, or when you were pregnant, or nursing a child." Extended use of oral contraceptives is defined here as use of oral contraceptives for 7 or more years during each of the decades when the women were aged 20–29 and 30–39 years, respectively (that is a minimum of 14 years use when aged 20–39).[12]

Analytical cohort

There was a total of 46,334 women aged 40 to 99 at enrollment who gave information about marital status, whether they had ever given birth to a live child, and their BMI at age 20. Less than 0.5% of the women in this cohort gave birth to their first child when aged 41 or above, thus the nulliparity prevalence from the women closely reflects the lifetime prevalence. Subjects with outlier values of estimated BMI that most likely reflected severe illness or incorrect self-reported data ($< 16.0\,kg/m^2$ or higher than $60.0\,kg/m^2$) were excluded. In order to ascertain that the childbearing had no influence on the BMI at age 20, only nulliparous women and women who gave birth to their first child when aged 21 or above were included in our analyses. Thus, 13,175 women with early ($n = 9879$) or unknown ($n = 3296$) age at first delivery were excluded. A total of 33,159 women were finally included in the analyses.

Statistical analyses

The dependent variables in this cross-sectional study were nulligravidity and nulliparity (defined as never having delivered a live child), as well as never having a second or third child (given a first or second child, respectively). The main independent variable was BMI at age 20. BMI was categorized into six BMI (kg/m^2) groups: BMI < 18.5, $18.5 \leq$ BMI < 20, $20 \leq$ BMI < 25, $25 \leq$ BMI < 30, $30 \leq$ BMI < 32.5, and BMI ≥ 32.5. These groups are in accord with the main groups recommended by the World Health Organization (WHO) for classification of underweight, normal weight, overweight, and obesity (< 18.5, 18.5–24.9, 25–29.9, ≥ 30), but the present classification is more detailed. WHO defines obesity class 1 as BMI 30–34.9 kg/m^2. However, only 0.8% of the women had

Table 1. Relationships Between Body Mass Index at Age 20 and the Likelihood of Never Having Been Pregnant or Being Nulliparous at Age 40[a]

	N	Body mass index (kg/m^2) at age 20: <18.5	18.5–19.9	20–24.9	25–29.9	30–32.4	≥32.5	p value
No. of women (%)	33,159	4824 (14.5)	7268 (21.9)	17,936 (54.1)	2363 (7.1)	340 (1.0)	428 (1.3)	
Nulligravidity								
Nulligravidity	33,159	1.13 (1.02, 1.24)	1.04 (0.95, 1.13)	1.00	1.42 (1.26, 1.61)	1.68 (1.26, 2.24)	2.82 (2.23, 3.56)	< 0.0001
Nulligravidity[b]	32,316	1.18 (1.06, 1.30)	1.04 (0.95, 1.14)	1.00	1.51 (1.34, 1.71)	1.92 (1.44, 2.57)	3.18 (2.50, 4.05)	< 0.0001
Nulligravidity[c]	32,129	1.21 (1.10, 1.34)	1.06 (0.97, 1.15)	1.00	1.52 (1.34, 1.72)	1.92 (1.43, 2.57)	3.13 (2.46, 4.00)	< 0.0001
Nulligravidity[d]	31,301	1.21 (1.09, 1.35)	1.05 (0.95, 1.14)	1.00	1.52 (1.34, 1.73)	1.87 (1.39, 2.51)	3.12 (2.44, 3.99)	< 0.0001
Nulliparity								
Nulliparity	33,159	1.12 (1.03, 1.21)	1.04 (0.97, 1.12)	1.00	1.36 (1.22, 1.51)	1.71 (1.33, 2.20)	2.46 (1.98, 3.07)	< 0.0001
Nulliparity[b]	32,316	1.12 (1.03, 1.22)	1.04 (0.97, 1.12)	1.00	1.37 (1.23, 1.53)	1.71 (1.33, 2.21)	2.47 (1.97, 3.09)	< 0.0001
Nulliparity[c]	32,129	1.16 (1.06, 1.26)	1.06 (0.99, 1.14)	1.00	1.36 (1.22, 1.52)	1.70 (1.31, 2.20)	2.39 (1.91, 2.99)	< 0.0001
Nulliparity[d]	31,301	1.15 (1.05, 1.25)	1.05 (0.98, 1.14)	1.00	1.38 (1.23, 1.54)	1.67 (1.28, 2.16)	2.40 (1.92, 3.02)	< 0.0001

[a]Odds ratio (95% CI). Adjusted for age when completing the questionnaire and marital status.
[b]Also adjusted for ever smoking, ever use of alcohol, ethnic background (blacks vs. other), and level of education.
[c]Also adjusted for ever smoking, ever use of alcohol, ethnic background (blacks vs. other), level of education, as well as age at menarche.
[d]Also adjusted for ever smoking, ever use of alcohol, ethnic background (blacks vs. other), level of education, as well as age at menarche and menstrual irregularities.

BMI at age 20 of $\geq 35.0\,kg/m^2$. Thus we defined BMI ≥ 32.5 kg/m^2 as the lower limit for our top BMI category.

In addition to age when completing the questionnaire (included in the multivariate model as 5-year age groups) and marital status (seven groups), the following variables were considered as possible confounders of the relationship between BMI at age 20 and childbearing: ethnic group (blacks vs. other), level of education, ever smoked, ever used alcohol, age at menarche, and menstrual irregularities. In addition, a number of stratified analyses were performed for these variables as well as extended use of oral contraceptives, problems becoming pregnant, miscarriages, and regular (monthly or more frequently) consumption of beverages containing caffeine.

The statistical analyses included cross-tabulations, analyses of variance, and logistic regression. Stratified analyses were conducted. Testing for nonlinear (e.g., U-formed) relationships were conducted by including a second order term (BMI at age 20 as categorized above squared) in the statistical model. The *p* values in the tables reflect the result of testing the hypothesis of any difference according to BMI (in six categories) rather than a linear trend over BMI categories; *p* values < 0.05 were considered statistically significant. Analyses were performed using SAS software.[14]

Results

A total of 7461 (23%) of the women included in the cohort were nulliparous at age 40 and 4954 women (15%) had never been pregnant. Women who were obese at age 20 were more likely to be relatively young when completing the lifestyle questionnaire, to have never been married, to have lower education, to be black, to have early menarche, and to report more menstrual irregularities. No relationship was found with extended use of oral contraceptives. Only 1% and 6% of the women, respectively, were current users of tobacco or alcohol. Two out of three women had never used alcohol, only 38% consumed beverages with caffeine monthly or more often, and 87% were never smokers. Ever use of alcohol or tobacco were both associated with obesity. Obese women were also more likely to drink beverages with caffeine monthly or more often.

Table 1 shows the relationships between BMI at age 20 and the likelihood of never having been pregnant or being nulliparous. All analyses are adjusted for the age when completing the questionnaire and marital status. The odds ratio for nulliparity in women with BMI ≥ 32.5 was 2.46 (95% CI: 1.98, 3.07), but was 3.24 (95% CI: 2.67, 3.93) in women with BMI ≥ 32.5 before adjustment for marital status. The relationships with never having been pregnant were somewhat stronger than those with nulliparity. There was also a statistically significant ($p < 0.001$) indication of a U-shaped relationship. Thus, the odds ratio for nulliparity in women with BMI < 18.5 was 1.12 (95% CI: 1.03, 1.21). Adjustments for a number of possible confounders in addition to age and marital status had only marginal influence on the relationships (Table 1).

However, if a woman had delivered one live child after the age of 20, the relationship between obesity at age 20 and never having a second child was weaker (though still significant) than that between BMI at age 20 and nulliparity. The association with underweight was similar to that for nulliparity. No

Table 2. Relationships Between Body Mass Index at Age 20 and the Likelihood of Not Having Any More Children According to the Number of Previous Successful Live Births[a]

No. live births*	N	Body mass index (kg/m²) at age 20 < 18.5	18.5–19.9	20–24.9	25–29.9	30–32.4	≥ 32.5	p value
0	33,159	1.12 (1.03, 1.21)	1.04 (0.97, 1.12)	1.00	1.36 (1.22, 1.51)	1.71 (1.33, 2.20)	2.46 (1.98, 3.07)	< 0.0001
1	25,698	1.16 (1.05, 1.28)	1.05 (0.97, 1.15)	1.00	1.12 (0.98, 1.29)	1.19 (0.85, 1.67)	1.62 (1.19, 2.21)	0.0023
2	21,407	1.01 (0.93, 1.10)	1.03 (0.96, 1.10)	1.00	0.97 (0.87, 1.10)	0.99 (0.72, 1.36)	0.90 (0.66, 1.24)	0.92

[a]Odds ratio (95% CI). Adjusted for age when completing the questionnaire and marital status.
*Number of previous successful live births.

relationship was found between BMI at age 20 and the odds of having a third child in the women who had already given birth to two children (Table 2).

Adjustments of the relationships displayed in Table 2 for the same variables used for adjustment in Table 1 demonstrated little or no confounding by ever smoking or ever use of alcohol, ethnic background (black vs. other), education, age at menarche, or menstrual irregularities. Further adjustments for age at first delivery increased the odds ratio of never having a second child (to 1.8 [1.2, 2.4]) if the woman was obese, but had no impact on the lack of association between obesity and the odds of having a third child (results not shown).

A number of supplementary analyses of the relationship between BMI at age 20 and nulliparity were conducted in various strata of the analytic population (age, marital status, race, education, ever use of tobacco or alcohol, regular [monthly or more frequent] use of beverages containing caffeine, menstrual irregularities, reported problems getting pregnant, ever miscarriages, extensive use of oral contraceptives, and age at menarche). Some of these are presented in Table 3. There were only a few statistically significant ($p < 0.05$) interactions and when an interaction was indicated, only the strength of the relationship (the odds ratio estimates) differed, not the relationship qualitatively.

Table 3. Stratified Analyses of the Relationships Between Body Mass Index at Age 20 and Nulliparity[a]

	N	Body mass index (kg/m²) at age 20 < 18.5	18.5–19.9	20–24.9	25–29.9	30–32.4	≥ 32.5	p value
All women	33,159	1.12 (1.03, 1.21)	1.04 (0.97, 1.12)	1.00	1.36 (1.22, 1.51)	1.71 (1.33, 2.20)	2.46 (1.98, 3.07)	< 0.0001
Aged 40–54 at enrollment	14,278	1.07 (0.95, 1.21)	1.00 (0.90, 1.11)	1.00	1.50 (1.29, 1.74)	1.85 (1.33, 2.59)	2.38 (1.79, 3.17)	< 0.0001
Aged 55–69 at enrollment	11,176	1.23 (1.07, 1.41)	1.09 (0.96, 1.24)	1.00	1.44 (1.19, 1.76)	2.11 (1.31, 3.37)	2.84 (1.90, 4.26)	< 0.0001
Aged 70+ at enrollment	7705	1.05 (0.87, 1.27)	1.06 (0.91, 1.24)	1.00	1.01 (0.80, 1.28)	0.93 (0.47, 1.82)	2.14 (1.12, 4.10)	0.33
Married								
Never	2281	1.08 (0.78, 1.49)	1.04 (0.77, 1.39)	1.00	1.17 (0.83, 1.64)	2.13 (0.90, 5.06)	2.20 (1.15, 4.20)	0.12
Ever	30,878	1.12 (1.03, 1.22)	1.04 (0.97, 1.12)	1.00	1.39 (1.24, 1.55)	1.67 (1.28, 2.18)	2.51 (1.99, 3.16)	< 0.0001
Ethnic group								
Blacks	7184	1.01 (0.87, 1.18)	0.98 (0.85, 1.13)	1.00	1.06 (0.87, 1.29)	1.44 (0.94, 2.20)	1.94 (1.35, 2.79)	0.0066
Other	25,658	1.14 (1.03, 1.26)	1.06 (0.97, 1.15)	1.00	1.50 (1.32, 1.70)	1.84 (1.34, 2.51)	2.73 (2.07, 3.60)	< 0.0001
Extended use of OC[b]								
No	32,218	1.13 (1.04, 1.23)	1.03 (0.96, 1.11)	1.00	1.35 (1.21, 1.50)	1.67 (1.29, 2.17)	2.56 (2.04, 3.20)	< 0.0001
Yes	648	1.14 (0.70, 1.88)	1.25 (0.82, 1.93)	1.00	3.20 (1.57, 6.53)	2.52 (0.56, 11.4)	2.38 (0.57, 9.87)	0.03
Irregular periods								
Never	27,548	1.12 (1.02, 1.23)	1.07 (0.99, 1.16)	1.00	1.37 (1.21, 1.54)	1.92 (1.42, 2.58)	2.60 (2.00, 3.40)	< 0.0001
Ever	4593	1.03 (0.84, 1.27)	0.89 (0.74, 1.07)	1.00	1.40 (1.10, 1.80)	1.07 (0.65, 1.77)	2.15 (1.42, 3.25)	0.0002
Smoking								
Never	28,698	1.11 (1.01, 1.21)	1.03 (0.95, 1.11)	1.00	1.43 (1.27, 1.61)	1.97 (1.48, 2.62)	2.62 (2.01, 3.41)	< 0.0001
Ever	4287	1.18 (0.96, 1.46)	1.16 (0.97, 1.39)	1.00	1.04 (0.80, 1.36)	1.00 (0.59, 1.72)	2.04 (1.37, 3.03)	0.012
Alcohol								
Never	21,811	1.11 (1.00, 1.23)	1.03 (0.94, 1.13)	1.00	1.45 (1.27, 1.67)	1.82 (1.28, 2.59)	2.70 (1.97, 3.69)	< 0.0001
Ever	11,128	1.13 (0.99, 1.30)	1.05 (0.94, 1.18)	1.00	1.18 (1.00, 1.40)	1.55 (1.08, 2.22)	2.19 (1.61, 2.98)	< 0.0001
Never used tobacco or alcohol	21,220	1.10 (0.99, 1.23)	1.04 (0.94, 1.14)	1.00	1.47 (1.28, 1.69)	1.75 (1.20, 2.53)	2.70 (1.94, 3.77)	< 0.0001

[a]Odds ratio (95% CI). Adjusted for age when completing the questionnaire and marital status.
[b]Used oral contraceptives (OC) for 7 or more years both when aged 20–29 and when aged 30–39.

In addition, we performed similar stratified analyses for the dependent variables nulligravidity and never having a second child if primiparous, respectively. As for the analyses for nulliparity, few significant ($p < 0.05$) interactions were found.

In a separate set of analyses, we also included women with unknown age at first delivery and women who gave birth to their first child when they were 20 years or younger. Relationships for nulliparity were very similar to those presented in Table 1, although the strength of the relationships were, as expected, somewhat weaker; OR (95% CI) 2.1 (1.7, 2.6) vs. 2.5 (2.0, 3.1) in women with BMI $\geq 32.5\,kg/m^2$ compared with women with BMI of 20–24.9 kg/m^2.

Discussion

Main findings

In this large study of Adventist women aged 40 and above, obesity at age 20 years was associated with increased risk of never becoming pregnant or giving birth to a live child (nulliparity). Our results confirm and significantly extend some of the results from previous studies; that is, obesity is a risk factor for nulliparity[3–5] and nulligravidity.[5] Our finding of a lesser impact of obesity on the likelihood of giving birth to a second or third child are at variance with some previous studies.[3,4]

We have previously shown that a number of variables that may be important for reproduction are related to BMI in this population.[12] Stratified analyses confirmed that the relationships did not differ according to a number of possible confounders. Thus, it is unlikely that, for example, smoking or alcohol can explain these associations.

The detrimental effect of obesity at age 20 on fertility seems to particularly reduce the ability to become pregnant or to deliver the first child; the effect is weaker for later deliveries (Table 2). Thus, our results suggest that there is a subgroup of obese women who have major problems in becoming pregnant and giving birth to a live child, whereas other obese women who have already had one or two children have less or no problem with further childbearing. One previous study found indications of a stronger impact of adolescent BMI on the likelihood of producing a second or third child compared to a first child,[3] and another reported a statistically significant lower probability of giving birth to a first and third (but not second and fourth) child in women who were obese when young.[4] The point estimates in the latter study, however, gave no indications of attenuated relationships for the third or fourth child compared to the first.

The explanation for the different findings in our study compared to these two studies is not obvious. It is possible that as the weight changes (in most cases weight increase) with age and with each delivery,[15,16] the BMI at age 20 when the women were nulliparous is a less precise measure of the prepregnancy BMI in the second and later pregnancies.

Since women tend to gain weight after pregnancy,[15,16] we excluded women who gave birth to a child at age 20 or before because BMI at age 20 was the main exposure variable. The consistent finding of a stronger relationship between obesity and never becoming pregnant as compared to never giving birth to a live child, further suggests that obesity is a more important determinant of the ability to become pregnant than remaining pregnant. This is in accordance with our findings from this cohort relating BMI at age 20 to the risk of miscarriages and reported problems of becoming pregnant.[12]

A U.S. study (the SWAN cohort) found a reduction of borderline statistical significance in the risk of nulliparity in women who were underweight when attending high school,[5] whereas two other studies found slightly reduced probability of having the first child in women who were underweight in adolescence.[3,4] The weak impact of underweight (12% increased odds in our data) on the risk of never giving birth to a live child (Table 1) seems to be compatible with the results from these two studies.

Explanations for the findings

Polycystic ovary syndrome (PCOS) may play a role as one explanation of the findings. PCOS affects 5%–10% of women in a general population and is associated with obesity.[17,18] In an unselected population, it was found that 42% of the PCOS patients were obese.[18] The syndrome includes anovulation and hyperandrogenism. It is also associated with insulin resistance.[17,19] Obesity also affects the hypothalamic-pituitary-ovarian axis, and thereby ovulation, as well as oocyte maturation and quality.[19] Another explanation for our findings could be depressed thyroid function because change in weight associates positively with change in thyroid stimulating hormone.[20] The relationships between thyroid hormones and obesity are complex, however.[20–22]

One possible explanation for the higher nulligravidity and nulliparity rate in women who reported low weight may be that this group included some women with eating disorders, in particular anorexia nervosa, who had amenorrhea.[2,23]

Relationships between BMI as a young woman and the risk of reporting irregular periods or miscarriages have been discussed elsewhere.[12] However, adjustments for menstrual irregularities did not markedly confound or alter the relationships between body mass at age 20 and the risk of never giving birth to a child (Tables 1 and 3).

Psychological and sociological explanations for our findings should also be considered. Some data suggest that obese, sexually active women have intercourse less frequently than slim women,[24] and obese women in our cohort were less likely to ever had be married. We adjusted for this confounder. Adolescent body weight has been found to predict the probability of finding a partner, with both underweight and obesity reducing this probability.[3] The group of women who never marry probably includes both those who never had a male partner and lesbian women and many of those who never tried to become pregnant. The relationship between BMI at age 20 and childbearing was clearly not due to women who never married or those who used oral contraceptives for many years (Table 3).

Limitations

This study has some weaknesses. The women were asked to recall their weight many years earlier, when they were 20 years old. Some women took part in both this Adventist Health Study (AHS-2) and the former study (AHS-1 in 1976). Strong correlations were found between weight recalled in 2002–2007, but pertaining to the 1970s, and weight that was stated in the 1976 AHS-1 questionnaires, thus some 30 years earlier ($r = 0.82$ for all women and $r > 0.80$ in every age group).[25] Thus, classification of recalled BMI at least in terms of relative rank appears to be quite good for recall of 25–30 years. However, validity may be less in elderly women recalling over 50 years. Subjects who were obese when they completed the questionnaire (and thus more likely to be overweight also at age 20) were more likely than leaner subjects to underestimate body weight when recalling it.[25]

If our results were to be explained by differential recall of weight at age 20, there would have to be a very strong correlation between never becoming pregnant or giving birth to a child and falsely recalled overweight and obesity when aged 20 years old. This does not seem likely.

The women were not asked about height at age 20, only about current height. This information was used when computing the body mass earlier in life, at age 20. There is an age-related decrease in height, particularly in women after the age of 50, resulting in a somewhat overestimated BMI at age 20. However, the associations were independent of age at enrollment, and thus time since the women were 20 years old, demonstrating that little bias is introduced when applying current height to the computation of BMI at age 20.

We have no data on the age at which women first became pregnant, only that of the age at first and later deliveries of live children. Thus, it is possible that some of the women classified as having been pregnant at least once, but nulliparous (a total of 2507 or 8% of all women in this cohort), may have been pregnant before they were 20. It seems unlikely, however, that these early pregnancies had much impact on the BMI at age 20.

There is a positive relationship between BMI in spouses,[24,26] and obese men also have lower fertility than other men.[1,4] Since we are not able to link spouses in our database, we cannot adjust for obesity in the male partner.

Overweight women tend to underestimate their weight, whereas underweight women overestimate it.[27] However, measured and self-reported BMI has been found to be highly correlated (Spearman's correlation coefficient = 0.94) in this population.[28] We do not have information about the percentage of body fat or adipose tissue distribution, such as waist circumference. However, these measures were strongly correlated ($r = 0.84$ and $r = 0.93$, respectively) with BMI in U.S. women aged 20–39.[29]

If obese, parous women were relatively more likely to have died before they could be included in the study cohort (aged 40 and above), this may have created associations in the direction that we find. However, mortality in this relatively healthy group of subjects with low smoking prevalence is low, and the relationship between BMI at age 20 and nulliparity did not differ according to the age of the women when completing the questionnaire (Table 3). Furthermore, parity was found to have little impact on mortality in this cohort of Adventist women.[30] Thus, it is unlikely that survival bias has had much impact on our results.

The large majority, 72% of the women, stated that they were Seventh-day Adventists at ages 15–25 years, and the results of our study reflect the relationships in postmenopausal elderly women when they were in the childbearing ages. This was a time when the prevalence of obesity was lower than today. Both may hamper the generalizability of the results to all women in the United States today, but it is unlikely that Adventist women differ biologically from other women.

Since women with early (before the age of 21) first delivery are excluded from the analytic cohort, the results from the analyses may not represent the relationships in all women in the general population.

Strengths

The current study also has significant strengths. It has been conducted in a population in which 93% are, or have been, married and with a low prevalence of alcohol use and smoking. Thus, it is a population that may have the best fertility outcomes. Still, approximately 30% reported at least one miscarriage, and 19% stated that they had tried for one straight year or more to become pregnant and had not succeeded.[12] This study is also larger than previous studies[3–5] that have addressed these questions, which has allowed detailed stratified analyses, narrower confidence intervals, and the estimation of odds ratios in women who were underweight as well as different groups of obese women (both BMI in the 30–32.5 range and BMI ≥ 32.5). The relationships between BMI at age 20 and never having been pregnant, or to childbearing as shown in Tables 1 and 2 were found consistently in the different strata of the population. In particular, we were able to assess possible effect modification of by smoking,[6] alcohol,[31] and caffeine[32] because this study population is rather unique for a U.S. population with the relatively high proportion of subjects having abstained from alcohol and smoking their entire lives. Such effect modification was not found.

It is also a significant strength that black women constitute 22% of the analytic population. However, stratified analyses find few indications that ethnic background or marital status modify our findings.

Conclusions

Obesity as a young woman, at age 20, significantly increased the odds of never becoming pregnant and never giving birth to a child. However, for women able to give birth to one child, the BMI at age 20 is of less (but some) importance when predicting a second child, but has no association with the ability to have a third child, given two successes. Women who were underweight at age 20 years also had lower odds of pregnancy success, but the effects were much weaker. The associations were not explained by marital status and other possible examined confounders.

There is a need for further studies that investigate whether weight as a young woman has a different impact on the probability of having the first, second, or third child. Further investigations of these associations using different measures of under- and overweight (BMI, percent body fat, and adipose tissue distribution) in young women would also be informative. Obesity is prevalent in women in the reproductive age (aged 20–39),[10] and nearly one out of five U.S. women are obese when they become pregnant; in non-Hispanic blacks the prevalence is 29%.[11] Thus, these results underline the importance of a healthy weight in young women.

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Disclosure Statement

The authors have no conflicts of interest to report.

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