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The Influence of BMI Levels on Phases of the Menstrual Cycle and Presumed Ovulation

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Abstract

Obesity and high body mass index (BMI) are known to be risks for anovulation and infertility. Little is known about how BMI levels affect parameters of the menstrual cycle. The purpose of this study was to determine the influence of BMI on parameters of the menstrual cycle and the likelihood for ovulation. The participants in this study were 244 women between the ages of twenty and fifty-four (mean thirty years) who charted from one to thirty-six menstrual cycles (mean seven cycles) for a total of 2,035 cycles. Urinary luteinizing hormone (LH) threshold tests were used to estimate the day of ovulation and the lengths of the follicular and luteal phases. The 244 participants were classified as

normal weight with a BMI of 18.5–24.9 kg/m² (N = 141), overweight with a BMI of 25–29.9 kg/m² (N = 67), and obese with a BMI of 30 kg/m² or greater (N = 36). One-way ANOVA indicated that there was a significant difference between groups in length of the luteal phase ($F = 4.62$, $p < 0.01$) and length of menses ($F = 3.03$, $p < 0.05$). Odds ratio indicated that the combined obese and overweight group was 34 percent less likely to have a positive detected urinary LH surge. We concluded that obesity might contribute to infertility by shortening the luteal phase and decreasing the probability of ovulatory menstrual cycles.

Introduction

Obesity is a growing worldwide epidemic. According to the World Health Organization in 2008, over 1.4 billion adults, twenty and older, were overweight. This included 200 million men and almost 300 million women who were considered to be obese with a body mass index (BMI) over 30 kg/m².¹ Data from the National Health and Nutrition Examination Survey show that from 2009 through 2010, obese men made up 35.5 percent and obese women comprised 35.8 percent of people in the United States alone.² The number of chronic diseases related to obesity is extensive with obesity being a risk factor for cardiovascular disease, hypertension, non-insulin dependent diabetes, dyslipidemia, arthritis, and some cancers. In addition to these co-morbidities, obesity has long been thought to affect women's reproductive health. In fact, much research has been performed focusing on the relationship between body weight and fertility in women with many studies showing links between obesity and infertility.

Furthermore, there is some evidence that body weight influences the functioning of the menstrual cycle. Obese women have been found to have irregular menstrual cycles with increased incidences of oligomenorrhea or amenorrhea.³ Irregularities in ovulation have also been demonstrated,⁴ and obese women have higher rates of miscarriages.⁵ However, there is very little evidence regarding the influence that BMI has on the characteristics (or phases) of the menstrual cycle. Therefore, the purpose of this study was to evaluate the influence of BMI levels on the phases of the menstrual cycle, i.e., the length of the overall cycle, the length of the follicular and luteal phases, menses, and the likelihood of ovulation. A secondary purpose was to speculate if obesity has an effect on the ability to achieve pregnancy and whether alterations in luteal function play a role in this effect.

Materials and Methods

Study Design

This was a retrospective study of 234 women who prospectively self-monitored their menstrual cycles for fertility parameters and who contributed fertility and menstrual data to an online registry throughout metropolitan Milwaukee between 2008 and 2012 for general research purposes. Participants were self-chosen to participate in data collection. Data collected represented 2,035 menstrual cycles with one to thirty-six menstrual cycles per subject (mean 7.2, $SD = 5.9$). The study was approved by the Marquette University Institutional Review Board and participants provided informed consent prior to providing data to the registry. The participants were registered in an online natural family planning website hosted by the Marquette University Institute for Natural Family Planning. Data was made available to the authors through the Marquette University Institute for Natural Family Planning. Data in the registry involved forty-nine variables including age of the participant and spouse, menstrual cycle parameters, height, weight, BMI, and pregnancy history. For this study, age, BMI,

gravidity, parity, length of menstrual cycle, length of follicular phase, estimated day of ovulation based on urine luteinizing hormone (LH) threshold self-test, and length of menses were evaluated.

Definitions of Dependent (Outcome) Variables

Length of menstrual cycle was counted from the first day of recorded menses up to and including the day before the next menses.

Length of follicular phase of the menstrual cycle was counted from the first day of recorded menses up to and including the day after the positive urinary threshold surge.

Length of luteal phase of the menstrual cycle was counted from the day after the positive urinary LH test up to and including the day before the next menses. The menstrual cycles with no LH surge detected were excluded from the analysis of the phases of the menstrual cycle.

Estimated day of ovulation (i.e., presumptive ovulation) was the day after the first positive urinary LH test.

Participants

Women agreed to provide data to the registry for research purposes. Many of the participants had personal interest in monitoring their fertility status for purposes of achieving or avoiding pregnancy. Ages of the participants ranged from 20 to 54 years (mean 30.3, $SD = 5.9$). Participants had varied menstrual, pregnancy, and delivery histories. They had a mean of 2.2 pregnancies ($SD = 2.2$; range 0–9) and a mean of 1.9 living children ($SD = 1.9$; range 0–8). Of the participants, 63 percent had at least one pregnancy, and 60 percent had at least one delivery.

Fertility Monitoring

Menstrual and presumptive ovulatory data were self-recorded online daily by subjects using an online menstrual cycle charting system. Presumptive ovulatory data (urinary LH and conjugated estrone [estrone-3-glucuronide]) was obtained by use of the Clear Blue Fertility Monitor manufactured by Swiss Precision Diagnostics. Participants tested their first void concentrated urine in the morning from day six of the menstrual cycle through the next twenty days or until a positive LH surge was detected.

Statistical Analysis

Information from each participant was entered into a data file by a research assistant using the seventeenth version of the Statistical Package for Social Scientists. A one-way analysis of variance (ANOVA) was used to determine if there was a difference in menstrual cycle length, follicular phase length, luteal phase length, and length of menses among the three BMI groups (normal weight = 18.5–24.9 kg/m^2 , overweight = 25–29.9 kg/m^2 , obese = BMI of 30 kg/m^2 or greater). A post-hoc Tukey test was used to evaluate the differences in menstrual cycle phases between the BMI groups. Pearson's *Chi-square* test and odds ratios were used to determine the likelihood of ovulatory menstrual cycles between BMI groups with a statistical probability of $p < 0.05$.

Results

Description of Participants by BMI Group

Table 1 shows the age, parity, and gravidity status of the 244 participants by BMI level. Of note is that 42 percent (103/244) of the participants had BMI levels in the overweight or obese categories. There was a significant difference in the number of pregnancies among the three levels of BMI ($F = 2.23$, $p < 0.03$) with significantly more living children in the overweight and obese participants ($F = 4.23$, $p < 0.02$; post-hoc comparison $p < 0.05$).

Table 1 Age, gravidity, parity, and menstrual cycle parameters by BMI Category

	Normal BMI ($N = 141$) Mean/SD	Overweight ($N = 67$) Mean/SD	Obese ($N = 36$) Mean/SD
Age	29.7/6.2	31.4/5.5	30.8/5.2
Pregnancies	1.9/2.2	2.6/2.3	2.8/2.3
Living children	1.6/1.8	2.3/2.1	2.4/1.9
Menstrual cycle parameters			
Number of cycles	$N = 1077$	$N = 642$	$N = 314$
Length of cycle	29.0/3.8	29.2/3.9	29.4/4.2
Follicular phase	16.3/3.3	16.6/3.7	16.3/3.4
Luteal phase	12.7/1.9	12.3/2.1	12.5/2.1
Menses length	5.2/1.2	5.3/1.5	5.1/1.5

Menstrual Cycle Parameters by BMI Group

Table 1 also shows the phases of the menstrual cycle by BMI level. One way ANOVA indicated that there was a significant difference between groups in length of the luteal phase ($F = 4.62$, $p < 0.01$) and length of menses ($F = 3.03$, $p < 0.05$). Post-hoc testing (Tukey) showed that there was a significant difference in luteal phase length between the normal BMI group versus both the overweight and the obese groups ($p < 0.01$) and a marginally significant difference in length of menses ($p < 0.06$). There were no significant differences in length of cycle and length of follicular phase.

Likelihood of Ovulation

Chi-square analysis showed that there were significantly more menstrual cycles within the obese and overweight BMI groups that did not have a detected LH surge compared to the normal BMI group (*Chi-square* = 6.11, $p < 0.01$). There were only 69 cycles out of 737 without a detected LH surge in the normal BMI group (for a percentage of 9.4 percent), 48 cycles without an LH surge in the overweight group (10.3 percent), and 44 missing LH surges in the obese group for a percentage of 20.4 percent. The combined overweight and obese BMI classification cycles have 92 out of 680 cycles or 13.5 percent without a recorded LH surge. The odds ratio between the normal BMI group and the combined obese and overweight groups was 0.66 (95 percent CI = 0.48–0.92); that is, the combined obese and overweight group was 34 percent less likely to have a positive detected urinary LH surge (see table 1).

Discussion

It is noteworthy that the overweight and obese BMI categories had significantly more children than the normal weight BMI group. The relationship between higher BMIs and greater number of children can possibly be explained by weight gained during pregnancy that is retained. This was a finding observed in the SPAWN (Stockholm Pregnancy and Women's Nutrition) Study, which was a long-term study in which participants answered questionnaires to include their diet and activity surrounding the time of their pregnancy, and with a follow-up fifteen years later.⁶ However, the results could be confounded because the participants in the overweight and obese groups were older than the normal BMI group. The data from the older ages and greater number of pregnancies could have affected the outcomes.

In addition to this, the majority of obese women have normal ovulation,⁷ which leads us to believe that infertility is multifactorial. Our findings show that the luteal phase and length of menses is possibly affected by obesity and the overweight and obese participants were less likely to have menstrual cycles with a detected LH surge. This may be secondary to anovulation. Anovulation has been proposed as the likely mechanism for decreased fecundity in some studies, even in overweight and obese women with regular menstrual cycles.⁸

Other studies, as discussed, suggest that the causes of these findings are multifactorial. Insulin as it relates to insulin resistance and hyperinsulinemia has long been thought to play a major role in fertility.⁹ Hyperinsulinemia stimulates steroidogenesis in the ovarian thecal cells and decreases the synthesis of sex-hormone-binding globulin, which may directly contribute to androgen excess.¹⁰ Excess androgen production can cause premature follicular atresia and impede ovulation.¹¹ Women with polycystic ovarian syndrome are examples of women specifically known to have ovulatory dysfunction, which is associated with insulin resistance and hyperinsulinemia, decreased sex-hormone-binding globulin, and increased testosterone and dihydrotestosterone production.¹² Another proposed etiology suggests that obesity affects the hypothalamic-pituitary axis via estrogen excess. In obese women, there is an excess of free estrogen from peripheral androgen conversion and reduced gonadotropin-releasing hormone availability. Therefore, abnormal ovarian function results in anovulatory cycles.¹³ The ova itself is thought to have a diminished capability for fertilization.¹⁴ This current study did show an increased frequency of presumed anovulatory menstrual cycles in obese and overweight women compared with normal weight women. The poor ovulation and anovulation could result in a shortened menses. Furthermore, a shortened luteal phase is also reflective of poor ovulatory response as endocrinopathies or the ovulatory process including reduced LH, FSH, and prolactin levels, as well as a diminished effect of progesterone on the endometrium have been suggested as causes of defects in luteal phase.¹⁵

In addition, obesity is associated with a chronic systemic inflammatory response that also affects ovarian function. Oxidative stress and endoplasmic reticulum stress has been noted to damage follicular maturation.¹⁶ Analysis of ovarian cells and fluid in obese women indicate that there is lipid accumulation which is believed to cause inflammation.¹⁷

Of note, the mean values for the length of cycle and length of luteal phase (seen in Table 1) appear to be almost identical. Statistically, they are significantly different as there is enough variance between the BMI groupings to show a significant change. However, from a clinical perspective, the change is

small (i.e., less than a day). Therefore it is more important to monitor and look for trends in the direction of shorter luteal phases and particularly the finding that there were statistically less menstrual cycles with presumed ovulation which is noted by the absence of an LH surge.

Limitations of the Study

The main limitation of the study is that the participants were not randomized. They were self-selected and chose to participate to monitor their level of fertility for the purposes of achieving or avoiding pregnancy. This, however, is also seen as a positive aspect of the study as these women have a personal incentive that would contribute to more accurate and regular recording. In addition to this, it is not known whether or not the participants have a history of irregular menstrual cycles above the average population as women who have more irregular menses would likely be more apt to chart.

Another limitation is that we were not able to determine the incidence of luteinized unruptured follicles during the study as another consideration of anovulation. Documentation supporting the failure of these follicles to rupture would require serial ultrasounds of the follicles, which was not performed in this study. Furthermore, there might be other reasons for lack of a positive LH test, such as improper testing and surges that might occur in the afternoon or evening hours. Twice a day testing to increase self-detection of the LH surge is recommended.¹⁸ Also, evaluating the LH surge within specific BMI ranges in the future may help assess the decreased probability of the LH surge, and narrowing the age range of the women in the study may also help, as the number of luteinized unruptured follicles increases and duration of the luteal phase shortens in older women.

Practice Recommendations

The approach to obese women that present with fertility problems should be seen as potentially manageable. Though numerous studies have shown obesity to be closely linked to infertility, ovarian function and fecundity improve with weight loss in overweight and obese women.¹⁹ An advantage for women practicing ongoing fertility monitoring is the ability to postulate about the state of their menstrual cycle. Women with higher BMIs would be more likely to have oligomenorrhea or amenorrhea and a shorter duration of menses as well as a shorter luteal phase. Since diet, exercise, and life-style modification have shown obesity related infertility to be reversible in some cases, ongoing charting may show progressive clinical improvements associated with these factors which may correlate to improved fecundity. Though not included in our data set, it would be interesting to see if there are any correlations with the Billings Ovulation Method and other methods of natural family planning that track changes in cervical mucus.

Testing to exclude other medical conditions for infertility should also be performed. In addition to this, weight loss and exercise should be encouraged in women seeking to achieve pregnancy. A dietary regimen that allows women to decrease 500 to 1,000 calories per day has been recommended, as well as daily physical activity for thirty minutes.²⁰

Conclusion

The results of this study point to anovulation as a contributing factor to infertility as indicated by the greater percentage of anovulatory cycles among overweight and obese women when compared to women with a BMI in the normal range. Anovulation and poor ovulatory function might contribute to

shortened luteal phases and menses. Further studies are needed to determine the effects of obesity on parameters of the menstrual cycle and menstrual cycle functions.

Notes

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