Food intake changes across the menstrual cycle: A preliminary study

Zmiany spożycia żywności pomiędzy poszczególnymi fazami cyklu menstruacyjnego – badanie wstępne

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Abstract

Background. Recent studies have reported that hormonal changes during the menstrual cycle in women who do not receive hormonal therapy have a significant influence on their eating habits.

Objectives. The aim of this study was to evaluate the eating habits of women not receiving hormonal contraception in relation to menstrual cycle phases.

Material and methods. A two-part survey questionnaire was used as a study tool. Eating habits were analyzed with a 24-hour dietary recall questionnaire. The following macronutrients were calculated: daily energy value (kcal), and amounts (g, %) of protein, fat, carbohydrates, and sucrose. The study group comprised 77 college students with regular menstrual cycles. Exclusion criteria included the use of any oral contraceptive, the use of medication for any chronic disease, any eating disorder, and a lack of written informed consent.

Results. The median total energy intake from macronutrients was highest during the luteal phase. Median protein, fat, carbohydrate, and sucrose intake were also highest during the luteal phase. The percentage of energy intake from protein was lowest during the luteal phase and highest during the follicular phase. The percentage of energy intake from sucrose was highest during the luteal phase, which was significantly greater than that during the ovulation phase.

Conclusions. Eating habits could be influenced by hormone secretion throughout the menstrual cycle. Increased appetite was observed in the luteal phase. Total energy, fat, carbohydrate, and protein intake fluctuated across the menstrual cycle. Fat, protein, carbohydrate, and sucrose intake were highest in the luteal phase.

Key words: appetite, eating habits, food intake, menstrual cycle, calories

Streszczenie

Wprowadzenie. Ostatnie doniesienia wskazują, że zmiana wydzielania hormonów w poszczególnych fazach cyklu u kobiet niestosujących terapii hormonalnej wpływa na ich zachowania żywieniowe.

Cel pracy. Ocena zachowań żywieniowych kobiet w poszczególnych fazach cyklu menstruacyjnego w grupie kobiet niestosujących antykoncepcji hormonalnej.

Materiał i metody. Do badania wykorzystano kwestionariusz składający się z 2 części. Oceny żywienia dokonano za pomocą wywiadu o spożyciu z 24 godzin. Obliczono dzienną podaż energetyczną diety (kcal) oraz zawartość białka, tłuszczu, węglowodanów i sacharozy (g, %). Grupę badaną stanowiły studentki jednej ze szkół wyższych. Do badania włączono 77 kobiet mających regularny cykl menstruacyjny. Kryterium wykluczenia z badania było przyjmowanie każdego rodzaju doustnej antykoncepcji hormonalnej, jakichkolwiek leków stosowanych w leczeniu chorób przewlekłych, zaburzenia odżywiania oraz brak zgody na udział w badaniu.

Wyniki. Mediana podaży energii ze składników odżywczych była najwyższa w fazie lutealnej. W tej fazie zaobserwowano również najwyższe (mediana) spożycie białka, tłuszczu, węglowodanów i sacharozy. Procentowy udział energii pochodzącej z białka był najniższy w fazie lutealnej, a najwyższy w fazie folikularnej. Z kolei procentowy udział energii pochodzącej z sacharozy był najwyższy w fazie lutealnej i znacząco przewyższał udział energii z tego składnika w fazie owulacyjnej.

Wnioski. Zachowania żywieniowe mogą być kształtowane przez hormony wydzielane podczas cyklu menstruacyjnego. Wzrost apetytu zaobserwowano w fazie lutealnej. Wartość energetyczna diety oraz spożycie tłuszczu, węglowodanów i białka ulega wahaniom w trakcie cyklu menstruacyjnego. Spożycie tłuszczu, białek, węglowodanów i sacharozy było najwyższe w fazie lutealnej.

Słowa kluczowe: apetyt, zachowania żywieniowe, spożycie żywności, cykl menstruacyjny, kalorie

Introduction

Recent studies[1,2] have reported that hormonal changes during the menstrual cycle in women who do not receive hormonal therapy (contraception, hormone replacement therapy) have a significant influence on eating habits. Awareness of these changes can help women maintain normal weight by controlling food intake. Sex hormones (estrogen, progesterone) and neurotransmitters (serotonin) exert a significant impact on the hunger and satiety centers in the hypothalamus.[1,2] As a result, neurohormonal regulation determines eating patterns throughout the menstrual cycle. Sex hormones affect food intake and whole-body energy expenditure through their influence on hypothalamic neurohormones, and also affect a woman's mood.[1,3]

Estrogen, which is intensely secreted during the follicular phase, exerts various metabolic effects, increases protein synthesis in the liver, influences glucose and insulin concentrations (through a change in pancreatic beta-cell function) and reduces appetite. Estrogen also has a positive impact on a woman's psychological state during ovulation, resulting in increased interest in sex/reproduction and a reduced desire to eat.[1,3–5]

Increased progesterone secretion is observed during the luteal phase. The biological activity of progesterone is pleiotropic; it influences the reproductive organs, raises basal body temperature and accelerates the basal metabolic rate. Moreover, it increases protein catabolism, decreases serum amino acid concentration and increases tissue glycogen production in the pancreas. It also has diuretic effects and enhances both calcium and phosphorus excretion from the body.[6,7] Finally, it dampens the mood of women, and exacerbates anxiety and fatigue. These changes may be followed by increased carbohydrate intake (particularly simple sugars), which increases serotonin concentration in the hypothalamus and improves the woman's mood. Existing studies have revealed that during the luteal phase women consume more sweets and carbohydrate-based foods.[1,5]

Serotonin in high concentrations exerts anorexigenic effects, inhibits carbohydrate and fat intake, and stimulates protein intake at the same time.[8] Serotonin release in the hypothalamus is reduced during the luteal phase, resulting in increased food consumption.[8]

The premenstrual syndrome (PMS) occurs 7–10 days before menstruation. This syndrome is connected with behavioral, somatic and physical symptoms. Many symptoms are associated with PMS, including irritability, mood swings, water retention, breast tenderness, and bloating. The PMS may predispose women to changes in appetite and food cravings.[8]

The aim of this preliminary study was to evaluate the eating habits (appetite and the nutritional value of the diet) of women not receiving hormonal contraception, in relation to the phases of the menstrual cycle.

Material and methods

Material

The study recruited 113 healthy students of dietetics, from whom 77 women with regular menstrual cycles (22–36 days) within the prior 6 months were enrolled. Exclusion criteria included the use of oral contraception, the use of medication for any chronic disease, the use of diet supplements, any eating disorder, any dietary restrictions, inability to determine the phases of the menstrual cycle, or a lack of written informed consent.

The participating women declared that they had moderate levels of physical activity and average stress levels during the observation period. All data gathered in the study was kept confidential. All the participants were introduced to the rules of the 24-hour dietary recall method and given written instructions on how to complete the 24-hour dietary recall questionnaire. An endocrinologist and gynecologist taught each participant how to recognize menstrual phases based on observation of mucus.

A two-part survey questionnaire was used as a study tool. The 1st part contained questions about age, anthropometric data, use of hormonal contraception, regularity and length of menstrual cycle, ovulation, PMS and its symptoms, and changes in eating habits observed throughout the menstrual cycle. In this part of the questionnaire, the respondents were asked to express their subjective feelings about their appetite during menstruation, ovulation and the luteal phase (a few days before the expected onset of menses) using the scale "decreased appetite", "increased appetite" or "no change".

Methods

The participants' body weight (in kilograms) and height (in centimeters) were measured at the start of the study. The body mass index (BMI) of each respondent was calculated using the generally adopted formula: BMI = body weight [kg]/body height [m^2]. The results were compared with the BMI classification approved by the World Health Organization (WHO): <18.5 kg/m^2 indicates underweight; 18.5–24.9 kg/m^2 is normal weight; 25.0–29.9 kg/m^2 is overweight; and ≥30.0 kg/m^2 indicates obesity.[9]

The 2nd part of the study focused on evaluating eating habits during 1 menstrual cycle. For this purpose, a 24-hour dietary recall questionnaire was administered. The questionnaire was prepared according to the recommendations of the Polish Institute of Food and Nutrition. Having read the appended instructions on how to complete the questionnaire, respondents completed the forms on their own by recording the meals and food products they consumed. They were obliged to indicate the amount of food consumed by measuring the weight or volume using cooking utensils. Each form dealt with a different menstrual cycle phase: form 1 (the follicular phase) was completed during the time between menstruation and the start of ovulation; form 2 (the ovulation phase) was completed during ovulation (mid-menstrual cycle); and form 3 (the luteal phase) was completed from the end of ovulation up to the 1st day of menstruation. Each woman declared regular menstrual cycle due to regular observation.

After completion, all the 24-hour dietary recall questionnaires were analyzed using Dieta v. 5.0 software (National Food and Nutrition Institute (Instytut Żywności i Żywienia), Warsaw, Poland). For each analyzed diet, the following parameters were calculated: daily energy value (in kilocalories), and the amounts of protein, fat, carbohydrates and sucrose, expressed in both percentages and grams. In total, 231 diets were studied, 77 of which dealt with the follicular phase, 77 with the ovulation phase and 77 with the luteal phase.

The study conformed to the Declaration of Helsinki and was reviewed by the local bioethics committee. Informed consent for the data analysis was obtained from all participants according to Polish law on patients' rights regarding data registration.

Statistical analysis

The statistical analysis was conducted using STATISTICA v. 10 PL software (StatSoft Inc., Tulsa, USA). The Shapiro–Wilk test was used to evaluate the normality of the distribution of the variables analyzed. In order to determine differences between study subgroups, the Kruskal–Wallis test for distribution other than normal and an analysis of variance (ANOVA) for normal distribution (analyzing differences in the mean values of the variables among at least 3 groups) were used. In order to determine differences in the variables between particular groups, Tukey's post hoc test was applied. A probability level of $p < 0.05$ was considered significant.

Results

The participants' baseline clinical characteristics are presented in Table 1. The majority of the study population had normal weight (72%). Symptoms of PMS were reported in 52 women (68%); the most frequently reported symptoms included increased appetite, stronger cravings for sweets, increased body weight, mood swings, irritation, flatulence, and constipation. Table 2 illustrates changes in the participants' appetite during each menstrual cycle phase.

Figure 1 depicts median energy intake during each menstrual cycle phase. The median energy intake value

Table 1. Participants' baseline clinical characteristics

Tabela 1. Charakterystyka badanej grupy

Variable		Value
Age [years] *Me* (Q_1–Q_3)		23 (21–24)
BMI [kg/m^2] *Me* (Q_1–Q_3)		23 (22–25)
Classification of weight status *n* (%)	underweight	1 (1)
	normal weight	55 (72)
	overweight	17 (22)
	obese	4 (5)
Women with premenstrual syndrome symptoms *n* (%)		52 (68)
Changes in eating patterns during menstrual cycle *n* (%)		47 (61)

n – sample size; *Me* – median; Q_1–Q_3 – interquartile range.

Table 2. Reported appetite changes during menstrual cycle phases

Tabela 2. Obserwowane zmiany apetytu w poszczególnych fazach cyklu

Appetite	Follicular phase		Ovulation phase		Luteal phase	
	n	%	*n*	%	*n*	%
Decreased	25	32	11	14	3	4
Increased	18	23	6	8	53	69
No change	45	34	60	78	21	27

was highest during the luteal phase. Median protein, fat, carbohydrate, and sucrose intake values also were highest during the luteal phase (Fig. 2–5).

Table 3 illustrates percentages of protein, fat and carbohydrate (including sucrose) intake during each phase of the menstrual cycle, as well as the results of the statistical analysis regarding differences between the variables studied. Differences were revealed with regard to the median percentages of protein and carbohydrate intake throughout the menstrual cycle. The percentage of energy intake from protein was lowest during the luteal phase and highest during the menstrual phase. The percentage

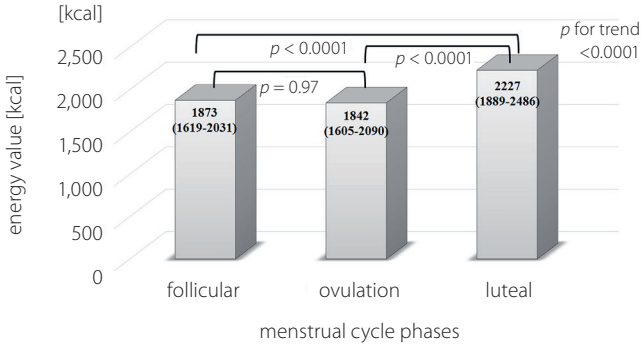

Fig. 1. Energy value in the diet over the course of the menstrual cycle. Values are presented as *Me* (Q_1–Q_3)

Ryc. 1. Wartość energetyczna diety w poszczególnych fazach cyklu. Dane prezentowane jako *Me* (Q_1–Q_3)

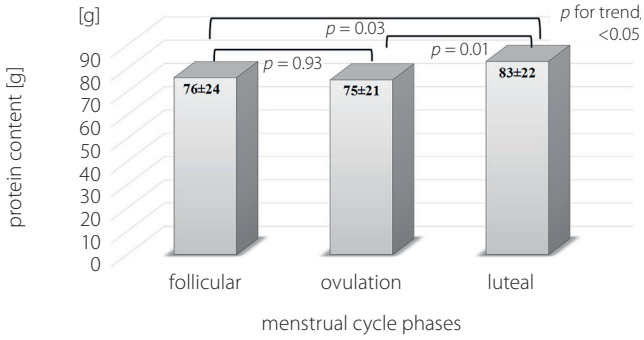

Fig. 2. Protein content in the diet over the course of the menstrual cycle. Values are presented as a mean and standard deviation (*M*±*SD*)

Ryc. 2. Zawartość białka w diecie w poszczególnych fazach cyklu. Dane prezentowane jako średnia oraz odchylenie standardowe (*M*±*SD*)

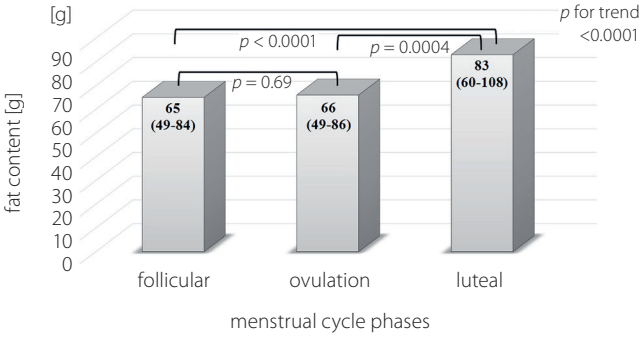

Fig. 3. Fat content in the diet over the course of the menstrual cycle. Values are presented as *Me* (Q_1–Q_3)

Ryc. 3. Zawartość tłuszczów w diecie w poszczególnych fazach cyklu. Dane prezentowane jako *Me* (Q_1–Q_3)

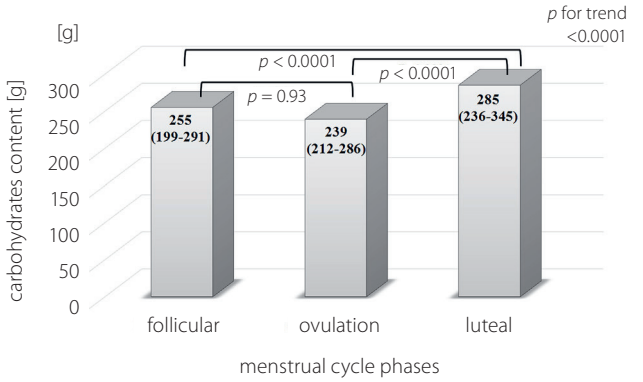

Fig. 4. Carbohydrates content in the diet over the course of the menstrual cycle. Values are presented as *Me* (Q_1–Q_3)

Ryc. 4. Zawartość węglowodanów w diecie w poszczególnych fazach cyklu. Dane prezentowane jako *Me* (Q_1–Q_3)

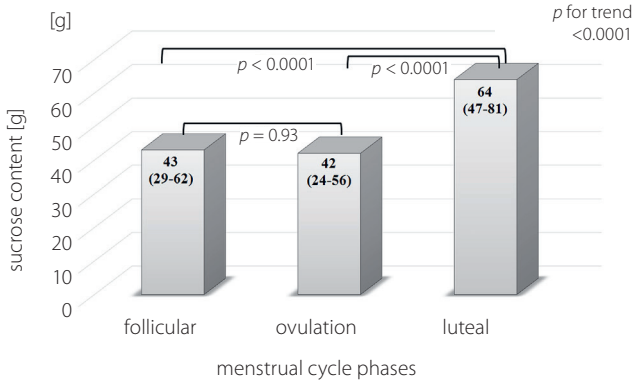

Fig. 5. Sucrose content in the diet over the course of the cycle. Values are presented as *Me* (Q_1–Q_3)

Ryc. 5. Zawartość sacharozy w diecie w poszczególnych fazach cyklu. Dane prezentowane jako *Me* (Q_1–Q_3)

of energy intake from sucrose was highest during the luteal phase (median: 11%; range: 9–15%), which was significantly greater than during the ovulation phase (median: 9%; range: 6–12%) (Table 3).

Table 3. Percentages of protein, fat and carbohydrates (including sucrose) in the participants' diets during the 3 menstrual cycle phases. Values are presented as *Me* (Q_1–Q_3)

Tabela 3. Procentowy udział energii pochodzącej z białka, tłuszczu i węglowodanów (włącznie z sacharozą) pomiędzy poszczególnymi fazami cyklu w badanej grupie kobiet. Dane prezentowane jako *Me* (Q_1–Q_3)

Parameter	Follicular phase	Ovulation phase	Luteal phase	*p* for trend
Protein	17 (14–20)*	16 (14–19)	15 (13–17)*	0.03
Fat	34 (24–39)	32 (28–39)	34 (28–40)	0.22
Carbohydrates (including sucrose)	52 (46–55)	50 (45–55)	50 (44–57)	0.68
sucrose	10 (7–15)	9 (6–12)**	11 (9–15)**	0.02

* $p = 0.02$; ** $p = 0.01$.

phases. Most of the respondents reported no change in appetite during ovulation. Approximately half of them also reported no change in appetite during the follicular phase. Davidsen et al. stated that appetite is less intense during menstruation and during the later stage of the follicular phase. However, women tend to experience increased cravings, particularly for products containing carbohydrates and fats, during the luteal phase.[5] Appetite has objective and subjective characteristics that control the amount and type of food consumed, and there are many factors that contribute to increased and decreased appetite. One of the main factors is hormone fluctuation throughout the menstrual cycle, which affects food intake and, therefore, eating patterns (amount, type, timing).[8] Primarily, increased progesterone concentration during the luteal phase has been found to be associated with increased food intake, whereas increased estrogen concentration during the follicular phase has been found to be associated with decreased food intake.[10] Moreover, it is well known that sex hormones also influence appetite peptides such as ghrelin, leptin, glucagon-like peptide-1, cholecystokinin, and peptide YY.[11]

With regard to daily energy value, we found associations between energy intake and the menstrual cycle phase that reflected fluctuations in appetite. Over half of the respondents consumed daily food ratios of higher energy value during the luteal phase. The difference in average dietary energy intake between the luteal and ovulatory phases amounted to 385 kcal, while that between the luteal phase and menstruation was 354 kcal. Daily energy intake was lowest during the follicular and ovulatory phases. Our results agree with those of Li et al., who demonstrated higher daily energy intake during the luteal phase compared with the follicular phase; the difference in energy intake between these 2 phases amounted to 214 kcal.[2] Chung et al. reported that regardless of body weight, women consumed more total calories (+160 kcal/day; $p < 0.05$) during the luteal and ovulatory phases compared with the follicular phase; in addition, a higher percentage of energy was consumed as carbohydrates during the follicular phase (+5% of total energy intake; $p < 0.01$).[4] Chung et al. determined that the average total energy intake of their 39 subjects across the menstrual cycle was 1,671 ±399 kcal/day, with the highest intake during the luteal phase (1,753 kcal/day; $p < 0.03$).[4]

Dye et al. reviewed 30 studies that included 37 groups of women and reported that energy intake was higher in the luteal phase than in the follicular phase in 27 groups.[8] This phenomenon has been termed "luteal hyperphagia", during which energy intake has been reported to increase by as much as 90–500 kcal/day compared with the follicular phase.[2,5,12,13] In contrast to our study, Gorczyca et al. reported that despite increased protein intake (specifically – animal protein) and reported food cravings in the luteal phase, the mean energy intake was similar throughout the menstrual cycle (1,600 kcal/day vs 1,591 kcal/day vs 1,591 kcal/day vs 1,661 kcal/day; *p*-value for trend = 0.20 for menstrual, follicular, periovulatory, and mid-luteal phases, respectively).[14] Surprisingly, Elliott et al. found that energy intake was higher in the follicular phase than in the luteal phase (6,959 kJ vs 5,792 kJ; $p < 0.05$).[15] However, this pattern was not replicated in the 2nd cycle of their study. The significant decrease in energy intake in the luteal phase of cycle 1 appeared to be associated with a corresponding decline in fat intake. The authors speculated that there might be a reduced preference for fat during the luteal phase.[15]

With regard to carbohydrates, we found no significant difference in the percentage of contribution to energy intake among the phases of the menstrual cycle, but average sucrose intake expressed in grams during each phase differed significantly. In contrast to the cyclic effects on total energy intake, reports on the patterns of macronutrient intake (including carbohydrates) during the menstrual cycle are less consistent.[8]

However, there are inconsistencies both between and within studies. As in our study, results may differ depending on whether the actual intake (in grams) of a macronutrient or the relative proportion that the macronutrient contributes to the total percentage of energy intake is considered. While absolute intake may increase significantly from the follicular phase to the luteal phase, the percentage of energy intake may fail to differ.[8]

Changes in carbohydrate quality during the menstrual cycle have also been observed, with predominant intake of simple carbohydrates from sweets in the luteal phase. The increase in carbohydrate consumption has been referred to as "carbohydrate craving" (defined as an intense desire for a particular food or type of food).[5,16] This change in dietary patterns, especially the intake of sweets, has also been associated with mood improvement during the luteal phase. It is believed that women increase carbohydrate consumption in the days prior to menstruation due to an unconscious effort to produce neurotransmitters related to mood improvement, since carbohydrates, especially simple carbohydrates, increase tryptophan availability, a precursor of serotonin in the brain.[17,18]

As far as fat intake is concerned, we determined that actual fat intake (in grams) was highest in the luteal phase. However, we failed to observe any significant change in the relative proportion that fat contributes to the total percentage of energy intake. Gorczyca et al. reported no changes in actual or relative fat intake throughout the menstrual cycle.[14] However, many authors have noted inconsistencies in macronutrient intake, including fat.[19–21] The changes observed may arise from hormone fluctuation or premenstrual stress. These, in turn, may be reflected in various aspects of eating, including changes in hunger, meal size, consumption of fat or carbohydrates, overall energy intake, or cravings for certain foods.[8] Karhunen et al. reported that higher serum leptin levels in obese women correlated with lower dietary energy intake and possibly lower preference for fat.[22] Premenstrual stress had a greater inverse relationship with overall energy, carbohydrate and fat intake than with protein intake.[15] Finally, we found significant differences in actual and relative protein intake throughout the menstrual cycle. Energy intake from proteins (as a percentage) was highest in the follicular phase and lowest in the luteal phase. One of the reasons protein intake declined in the luteal phase may be the increase in fat and carbohydrate intake during this time. McNeil and Doucet made similar observations.[23]

Study limitations

This study has several limitations. For example, each 24-hour dietary recall questionnaire concerning follicular, ovulation and luteal phases was completed only once. However, it is recommended that this questionnaire should be administered 3 times, after which an average value should be calculated and used in further analyses. Secondly, the respondents completed the questionnaire by themselves at home, following the appended instructions. Since most respondents were nutrition students, they knew how to complete the questionnaire correctly. However, daily sex hormone concentrations were not assessed. The authors relied on the knowledge of the study participants who declared that their menstrual cycles were regular, and on their ability to recognize the periovulatory phase based on self-observation.

Conclusions

We set out to investigate the dietary habits of women during the menstrual cycle. Our study offers several key findings. First and foremost, eating habits could be influenced by hormone secretion throughout the menstrual cycle. Secondly, increased appetite was observed in the luteal phase. Total energy, fat, carbohydrate and protein intake fluctuated across the menstrual cycle; fat, protein, carbohydrate, and sucrose intake were highest in the luteal phase. Finally, the association between eating habits and phases of the menstrual cycle highlights possible specific dietary recommendations that could help women maintain a stable body weight throughout the menstrual cycle.

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