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Changes in Taste and Food Intake during the Menstrual Cycle

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Abstract

Background: Dietary changes during the menstrual cycle may be the result of the interference of female hormones on taste; however, little is known about this possible relationship.

Objectives: The aim of this study was to evaluate the influence of the menstrual cycle on taste and food intake among young women.

Patients and Methods: Fifty women at childbearing age were followed during three months. Body mass index was used to assess the anthropometric nutritional status. Dietary intake was assessed by applying six dietary records. The taste of volunteers was evaluated in the luteal (LP) and follicular phases (FP) of the menstrual cycle through taste-intensity and constant stimulation tests. In the LP, blood was collected for determination of female hormones, insulin and ghrelin. Data are presented using descriptive statistics such as mean and standard deviation; ANOVA was used to compare means and significance level of 5% was adopted.

Results: The anthropometric nutritional status of volunteers remained unchanged during the studied phases. Protein was consumed in smaller amounts ($p < 0.05$) in the LP (LP: 66.66 ± 17.85 g/day and FP: 74.01 ± 16.57 g/day). The average intake of minerals such as potassium, calcium and magnesium were below of the recommendations, while sodium intake was above of the recommended values. In the LP, volunteers showed decreased sensitivity to acid taste. Positive associations in the LP were found between bitter taste perception and the following variables: energy intake ($r=0.49$; $p=0.01$), carbohydrate ($r=0.46$; $p=0.01$) and lipid ($r=0.39$; $p=0.04$). Positive association was found between bitter taste perception and insulin ($r=0.36$, $p=0.04$) and negative association between ghrelin and acid taste perception ($r=-0.36$, $p=0.04$).

Conclusions: The menstrual cycle changed the acid taste perception, which can affect the food choices in the luteal phase and suggests that hormones insulin and ghrelin can influence taste perception, controlling food intake.

Keyword: Menstrual Cycle; Taste; Food intake; Ghrelin; Insulin

Background

Changes in the food intake of women have been related to hormonal fluctuations resulting from menstrual cycle. The literature reports that during the menstrual cycle, women may experience changes in appetite and size of meals [1], changes in types of macronutrients consumed, in the selection of food to be ingested [2], food cravings and compulsion for certain foods [1,3,4].

According to Kuga, Ikeda [5], food choices can be influenced by changes in taste that seem to occur during the phases of the menstrual cycle. Basic tastes such as sweet, salty and bitter are influenced differently by serum levels of sex hormones during the menstrual cycle [6].

Changes in taste among healthy women during the menstrual cycle have been the subject of some studies, but the literature is scarce and little is known about the consequences of these changes on the nutritional status of women.

Objective

This work aims to evaluate the influence of the menstrual cycle on taste and its relation to food intake among young women and the relation between female sex hormones insulin and ghrelin to better understand appetite changes in these women, since such changes may lead to the development of obesity and non communicable chronic diseases.

Patients and Methods

This was an observational, longitudinal and randomized study with convenience sample. This study was conducted during 2013-2014, on 70 females aged from 20 to 40 years old, in which adult women were followed for a period of three months, with three complete menstrual cycles. Having briefed the subjects on the study, they enrolled for the research, if agreed to participate in the program. The inclusion criteria were regular menstrual cycle (average length 22-35 days), minimum age of 20 and maximum of 40 years, absence of disease and use of supplements. Exclusion criteria were being smoker, presence of fever, cold, flu or any complications in the oral cavity during the period of sensory analyses, since these factors could interfere with the perception of tastes [7].

The recruitment of subjects and the development of the study were

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conducted at the School of Nutrition, Federal Fluminense University (UFF), and Niterói – RJ. After clarification of the study purpose and use of data under the guarantee of anonymity and having provided the written informed consent the subjects were interviewed about their general and personal characteristics including information on lifestyle, age at menarche, onset of sexual intercourses and contraceptive use.

Seventy subjects were recruited and submitted to weight (kg) and height (m) measurements to calculate the Body Mass Index (BMI) in each phase: luteal phase (between days 24 and 27 of the cycle) and follicular phase (between days 10 and 12 of the cycle) of each menstrual cycle. Body weight measurement was carried out by means of bio-impedance scale Tanita Model TBF 350 – accuracy of 0.2 kg – at the Laboratory of Nutrition and Functional Assessment of the School of Nutrition - UFF (LANUFF) and height was measured using a audiometer.

The criteria of the World Health Organization (WHO) [8] were adopted for the classification of the nutritional status of subjects: BMI <18.5 corresponding to low weight; BMI ≥ 18.5 and <25 eutrophic; BMI ≥ 25 and <30 overweight and BMI ≥ 30 obese.

Dietary assessment was performed by applying three food records in the luteal phase (from days 24 to 27 of the cycle) and three in the follicular phase (from days 10 to 12 of the cycle) of each menstrual cycle, totaling 18 food records by subjects.

Data from food records were tabulated and analyzed using the NutWin® software - Nutrition Support Program. The consumption of energy, macronutrients and calcium, sodium, potassium and magnesium has also been assessed.

Sensory taste-intensity tests were performed for the screening of subjects with superior taste (ability to identify basic tastes) for the four basic tastes and constant stimulation test to evaluate sensitivity to tastes studied [9]. Sensory tests were performed at the Laboratory of Sensory Analysis (LABAs), Faculty of Nutrition, which occurred individually in appropriate and isolated booths with white light and at room temperature according to standards of the Brazilian Association of Technical Standards – ABNT [10]. Citric acid, sucrose, caffeine and sodium chloride were used for the preparation of aqueous solutions of acid, sweet, bitter and salty taste, respectively [11]. Solutions (500-mL) were prepared fortnightly and stored in glass jars properly identified and under refrigerated.

Sensory tests were applied in luteal phase (between days 24 and 27 of the menstrual cycle) and follicular phase (between days 10 and 12 of the menstrual cycle). The first test applied was the taste-intensity test to identify subjects who could identify the four basic tastes. To perform this test, solutions with two different concentrations of the four basic tastes were prepared: 2% and 4% sucrose; 0.14% and 0.2% citric acid; 0.07% and 0.14% caffeine and 0.2% and 0.4% sodium chloride [12]. These solutions were served in amounts of 20 mL at room temperature in a disposable white and odorless cups coded with three digits and randomly presented to volunteers, along with an evaluation form. The subjects were instructed to taste the samples, identify the tastes and select the most concentrated solution. Water was provided during the test for cleaning the oral cavity from one sample to another.

Fifty volunteers were considered with superior taste for basic tastes, who have achieved 100% accuracy. Only subjects with superior taste were able to perform the constant stimulation test.

For the constant stimulation test, increasing series of four concentrations of each distinct taste were offered to volunteers, along with a standard solution (water) as described by Dutcosky [9] with adjustments in the following concentrations: citric acid to 0% (water), 0.035%, 0.07%, 0.105% and 0.14% sucrose to 0% (water), 0.5%, 1%, 1.5% and 2%; caffeine to 0% (water), 0.017%, 0.035%, 0.0525% and 0.07% and sodium chloride at 0% (water), 0.05%, 0.1%, 0.15% and 0 2%. Solutions were served at room temperature in disposable, white and odorless cups containing 20 mL of each solution coded with three digits, following the order of increasing physical concentration. The subjects were asked to indicate on the evaluation sheet the concentration of the solution in which they perceived the tastes offered. Water was provided during the test to minimize the effect from one sample to another.

The taste-intensity and constant stimulus tests were not performed on the same day in order to avoid induced errors of sensory analysis due to continuous stimulation [9].

Biochemical evaluation was performed only during the luteal phase (between days 24 and 27 of the menstrual cycle) due to resistance of volunteers to perform more than one blood sample collection.

Blood collection was performed by a trained technician via venipuncture with disposable syringe. About 10 mL of blood were collected after a 12-hour overnight fasting period. Serum and plasma obtained were divided into aliquots in micro tubes and frozen at -70°C.

The levels of hormones (progesterone, estrogen, insulin and ghrelin) were measured using a specific enzyme-linked immunosorbent assay (ELISA) kit with 0.5 sensitivity.

The results of this study are presented using descriptive statistics such as arithmetic mean and standard deviation. Analysis of variance (ANOVA) with repeated measures and Tukey's post-test was used. The Fisher exact test was used for comparison of frequencies. Pearson correlation was used to identify possible associations between taste, food intake and concentration of hormones during the menstrual cycle. The normality assumption (Gaussian distribution) of data was verified by Kurtosis and Skewness tests to support the use of statistical methods described above. To analyze data that were not normally distributed, the corresponding nonparametric test was applied. Data analysis was done using SPSS statistical software (version 18), tests with $P < 0.05$ was considered as statistically significant.

The study protocol complied with the ethical principles of the Declaration of Helsinki and the norms of Resolution 196/96 of the National Health Council, and was revised and approved by the Ethics Research Committee in Humans of the Antonio Pedro University Hospital, approved in the National Information System on Ethics in Research Involving Humans (SISNEP) under protocol number 0084.0.258.000-07.

Results

Most volunteers were unmarried college students, with average age of 23 years, with menarche at age of 12. The onset of sexual intercourse occurred around 18 years. About 20% of volunteers reported to be engaged in regular physical activity (average of 4 hours/week), while the majority (74%) did not perform any physical activity. Regarding the use of contraceptive methods, 64% of volunteers used only hormonal method; while 8% used the barrier method (condoms: 6% and IUD: 2%); 6% used both methods and 22% were not using any contraceptive method. The menstrual cycle had duration of 28 days, which can be considered normal. The general characteristics of subjects are shown in Table 1.

Regarding nutritional status, most of the subjects were eutrophic

Characteristics	Average ± SD
Age (years)	23.46 ± 5.29
Menarche (years)	12.52 ± 1.31
Beginning of sexual intercourse (years)	17.90 ± 2.11
Physical activity (hours/week)	4.37 ± 2.63
Menstrual cycle length (days)	28.37 ± 1.84

Table 1: General characteristics of the studied women (n=50).

(81.4%); however, some cases of low birth weight (9.3%), overweight (2.3%) and obesity (7%) were observed. There was no change in the nutritional status of volunteers between luteal (22.39 ± 4.17 kg/m²) and follicular phases (22.37 ± 3.82 kg/m²) during the studied period.

Table 2 shows the food intake of subjects in the luteal and follicular phases of the menstrual cycle. Protein intake was lower ($p < 0.05$) in the luteal phase (66.66 ± 17.85 g/day) compared with the follicular phase (74.01 ± 16.57 g/day). The ingestion of lipids and carbohydrates was similar between phases, as well as the energy intake.

No significant differences were observed regarding sodium, potassium, and calcium and magnesium intake between luteal and follicular phases; however, all these minerals were consumed in inadequate amounts by subjects during the studied period. The average sodium intake was above recommendation, while other minerals were consumed in amounts below of the Estimated Average Requirement (EAR) [13,14].

The perception of subjects to various concentrations of the basic tastes at the follicular and luteal phases of the menstrual cycle is shown in Table 3. Lower sensitivity to acid taste in the luteal phase ($p < 0.05$) was observed since a greater number of volunteers (33.3%) perceived acid taste in the highest concentrated solutions. Sweet, bitter and salty tastes were perceived similarly between phases.

Significant positive association between bitter taste perception and energy ($r=0.49$; $p= 0.010$), carbohydrate ($r=0.46$; $p=0.016$) and lipid ($r=0.39$; $p=0.045$) was observed in the luteal phase. There was no association between the perception of basic tastes and energy and macronutrient intake during the follicular phase. No associations between perception of these tastes and the intake of the minerals were found.

Serum levels of hormones evaluated during the luteal phase of the menstrual cycle are shown in Table 4. Estrogen level was within normal limits, but it was observed that 22.86% of participants had values below adequate limits. Similarly, the mean progesterone level was normal in most volunteers (60.53%), and 15.79% of them showed values above those considered suitable for the phase and 23.68% showed values below those considered appropriate for the phase studied.

The average insulin level was normal. Few cases of hyperinsulinemia (5.56%) and hyperinsulinemia (13.89%) were observed. The average ghrelin level was 178.11 (144.6 to 262.7) (Table 4).

No significant correlations were found between hormone levels and food intake. However, when hormones were correlated to taste, there was a positive association between insulin and bitter taste perception ($r=0.36$, $p=0.04$) and negative association between ghrelin concentration and sour taste perception ($r=-0.38$, $p=0.04$), both in the luteal phase of the menstrual cycle.

Discussion

In recent years, literature has proven what is empirically well known by women: changes related to the menstrual cycle, especially those related to food intake are often perceived weeks before menstrual bleeding [4].

The change in body weight is considered by some authors as one of physical aspects resulting from changes in the feeding behavior caused by menstrual cycle [1,5]. In the present study, no changes were found in volunteers' body weight, with stable BMI in the different phases of the menstrual cycle. These results are corroborated by Santos et al. [3], who assessed the nutritional status of young college women during the menstrual cycle.

In the luteal phase, women show greater preference for foods with high energy density, with consequent increase in energy intake [3]. Some researchers justify this increase in energy consumption as a way to offset the energy expenditure that occurs during this period [15], while other authors emphasize that the body has undiscovered forms of compensation that are related to further reduction of energy consumption in the follicular phase [16]; which may explain the body weight maintenance in the different phases. In the present study, no difference in energy consumption and BMI of women was observed

Intake	Luteal phase Average ± SD	Follicular phase Average ± SD
Energy (Kcal/day)	1705.15 ± 325.69	1694.35 ± 293.48
Carbohydrate (g/day)	226.40 ± 50.41	219.75 ± 42.28
Protein (g/day)	66.66 ± 17.85*	74.01 ± 16.57
Lipids (g/day)	61.63 ± 15.36	59.50 ± 13.94
Sodium (mg/dia)	1593.01 ± 488.63	1678.11 ± 579.38
Potassium (mg/dia)	1421.64 ± 301.40	1963.21 ± 155.48
Calcium (mg/dia)	579.40 ± 269.18	684.21 ± 234.01
Magnesium (mg/dia)	143.43 ± 31.85	178.24 ± 35.63

* Denotes significant difference between the phases ($P<0.05$).

Table 2: Food intake of subjects in the luteal and follicular phases of the menstrual cycle.

Taste	Concentration (%)	Frequency (%)	
		Luteal Phase	Follicular Phase
Acid	0.035	66.7	83.3
	0.0700; 0.1050 e 0.1400	33.3*	16.7
Sweet	0.5	33.3	36.7
	1.0; 1.5 e 2.0	67.7	63.3
Bitter	0.0175	73.3	73.3
	0.0350; 0.0525 e 0.0700	26.7	26.7
Salt	0.05	30	36.7
	0.10; 0.15 e 0.20	70	63.3

Table 3: Perception of subjects to different concentrations of acid, sweet, bitter, and salty taste in the luteal and follicular phases. *Significant difference between the phases ($P<0.05$).

Hormone	Reference value	Median (confidence interval)	Adequation
Estrogen (pg/mL)	13.0-146.0[a]	38.05 (27.0-49.1)	adequate: 77.14% below: 22.86%
Progesterone (ng/mL)	4.9-18.8[a]	12.9 (7.4-18.4)	adequate:60.53% below: 23.68% high: 15.79%
Insulin (µU/mL)	0.7-9.0[b]	2.82 (1.65-3.65)	adequate: 80.55% below: 13.89% high: 5.56%
Ghrelin (pg/mL)	ND*[c]	178.11 (144.63-262.7)	ND*

*ND: Not Determined; [a]Commercial Kit: DIAsource E2-EASIA; [b]Commercial Kit: AccuBind® ELISA - Monoblind Inc; [c]Commercial Kit: Human Ghrelin (total) Millipore.

Table 4: Serum progesterone, estrogen, insulin, and ghrelin level in the luteal phase of the menstrual cycle.

during the menstrual cycle. This result is corroborated by other studies evaluating women at childbearing age [2,17].

However, although there are still controversies related to changes in energy consumption in the different phases of the menstrual cycle, changes have been observed in the amount of ingested macronutrients throughout the cycle such as concomitant increase in the consumption of carbohydrates and lipids and reduction in proteins [1,4,17-19]. The present study found results similar to those reported in literature such as reduction in protein intake during the luteal phase. Some studies indicate reduction in protein intake days before menstrual bleeding [20] and in the bleeding period [21], as well as increase in the intake of carbohydrates and lipids [4,17-24].

The literature shows that not only the quantity but the quality of carbohydrates ingested has been evaluated. Changes in carbohydrate quality during the menstrual cycle have been observed, with predominant intake of simple carbohydrates from sweets and sugars in the luteal phase [3]. This change in the intake of macronutrients, especially those from sweets, has also been associated with mood improvement during this period. It is believed that women increase carbohydrate ingestion days prior to menstruation due to an unconscious search for production of neurotransmitters related to mood improvement, since carbohydrates, especially simple carbohydrates, increase the tryptophan availability, precursor of serotonin in the brain [25].

Regarding the intake of minerals, all elements studied were ingested in inadequate amounts throughout the cycle, indicating nutritional risk in this population. In relation to sodium intake, all participants had intakes above recommended values in both phases. In the study by Santos et al. [3], in women in the luteal phase, increased consumption of foods rich in sodium and fat was observed, which may be related to the appearance of certain symptoms of the pre-menstrual syndrome (PMS). One should also consider that high intake of this nutrient is related to the development of coronary heart disease and high blood pressure [26,27], hence the great importance of studies that can serve as basis for the development of programs for the nutritional counseling of women at childbearing age with or without symptoms of PMS.

Calcium intake during the study did not achieve adequate average recommendations, presenting high frequency of low intake, which result is in line with literature [28]. The intake of adequate amounts of this mineral, especially in women during adulthood is essential to prevent osteoporosis [28], since the calcium metabolism is influenced by female hormones [29]. Furthermore, inadequate intake of this mineral has been associated with symptoms of PMS [30]. According to clinical investigations conducted by Thys-jacobs [31], low calcium concentration can be involved in the etiology and emotional symptoms of PMS [31].

Similarly, magnesium consumed in insufficient amounts appears to influence the symptoms of PMS due to the reduction of its serum concentration. In the body, this nutrient is involved in functions such as regulation of serotonin and neurotransmitters. Thus, reduction in the magnesium concentration may trigger emotional symptoms related to PMS [32].

Studies have shown that changes that seem to occur in taste during the menstrual cycle can influence food intake among women [5]. Among tastes studied, the acid taste was the only that had its perception changed, with reduced sensitivity in the luteal phase. Kuga et al. [5] suggested that changes in taste may occur in the luteal and follicular phase, influencing the choice of foods to be ingested. Thus, it is suggested that the decreased sensitivity to acid taste possibly induces the search for foods containing this taste. Usually, foods with this feature are those at the top of the Food Guide Pyramid, which should be consumed with caution and moderation.

Foods with acid taste are often sugary or those with some degree of sweetness, such as citrus fruits, soft drinks and some candies. Studies on dietary intake during the menstrual cycle have found changes in the type of food selected during the cycle, with increased consumption of sweets and sugars [3]. Thus, it is suggested that decreased perception to acid taste in the luteal phase may reflect a possible search for sweet foods during this period.

In the present study, it was found that volunteers who had low serum progesterone concentrations only perceived salty taste at higher concentrations, while volunteers who had adequate serum concentrations of this hormone perceived salty taste at lower concentrations, which, in part, can justify the search of women for salty foods in the luteal phase of the menstrual cycle. In the study by Alberti-Fidanza et al. [6], where the sensitivity to tastes was analyzed, the authors concluded that the sensitivity to salty taste is impaired due to the progesterone concentration, and sweet and acid tastes can also be influenced by the hormones estrogen and progesterone, respectively. According to these authors, sensitivity to sweet taste is increased according to the estrogen levels and when progesterone concentration rises, sensitivity to bitter taste increases. These authors did not identify influences on sensitivity to acid taste.

Although no changes in the bitter taste perception have been identified, positive associations were found between bitter taste perception and the intake of calories, carbohydrates and lipids in the luteal phase of the menstrual cycle. It seems that the bitter taste induces food intake cession, when this occurs excessively. The bitter taste perception by the tongue is involved in inducing the finishing of the food intake. The identification of this taste causes an aversive response, so as to avoid the intake of food toxins, which usually have characteristic bitter taste [33-36]. Recent studies have evidenced the presence of bitter taste receptors elsewhere in the digestive system besides the oral cavity, such as in the intestine. These receptors have also been related to increased secretion of intestinal peptides responsible for reduced appetite such as cholecystokinin (CCK) and glucagon-like peptide-1 (GLP-1) [37].

It seems that in conjunction with the mechanism involved in food intake cession involving the bitter taste also involves hormone insulin. The anorectic effects of this hormone are well elucidated in literature [38]. According to the results found in this study, during the luteal phase, there is a trend of positive association between hormone insulin and the bitter taste perception. It is assumed that this hormone when in high concentrations leads to an increase in bitter taste perception, also increasing GLP-1, thereby increasing serum insulin levels and also delayed gastric emptying and induction of food intake cession.

Shin et al. [39] demonstrated the ability of ghrelin in modifying the gustative quality. According to these authors, ghrelin may be produced by taste receptors, with an effect on the perception of sweet, acid and *umami* tastes. In the present study, trend towards a negative association between hormone ghrelin and acid taste was identified, hypothesizing that high concentrations of this hormone lead to reduced acid taste perception.

In relation to female sex hormones and appetite regulators, no associations were found. These results corroborate those found by Dafopoulos et al. [40].

Conclusion

The present study suggests that there are changes in the sour taste perception in the luteal phase of the menstrual cycle, influencing the food intake of adult women, thus modifying their eating behavior, inducing improper food choices, which may compromise the health of these women, raising concern about the increased chances for developing chronic diseases and overweight/obesity. This study also suggests the possibility that hormones ghrelin and insulin influence taste, acting to control food intake.

The low consumption of calcium, magnesium and potassium throughout the menstrual cycle can be an indicator of poor dietary habits and also increases the likelihood of developing osteoporosis/osteopenia, while excessive sodium intake predispose women to the development of hypertensive diseases.

Thus, there is a need for the implementation of prevention actions and nutritional counseling for adult women at childbearing age, since their physiology exposes them to greater risk for the development of chronic diseases.

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