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ASSOCIATIONS BETWEEN MENSTRUAL CYCLE PHASE, PHYSICAL ACTIVITY LEVEL AND DIETARY MACRONUTRIENT INTAKE

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Abstract

The study was aimed at determining possible association between physical activity level, energy and macronutrient intake, and phases of the menstrual cycle (MC): follicular (FP) and luteal (LP), Eumenorrheic women (n=23) were studied; 12 were classified as physically active (PA) and 11 as physically inactive (PIA). Food consumption and basal body temperature were recorded daily throughout one complete menstrual cycle. Relative energy intake was greater (P<0.05) in the PA than the PIA group (34.2 and 27.8 kcal/kg-body weight/day, respectively). Significantly (P<0.05) more carbohydrate (CHO) was consumed by both groups in FP (61.2%) vs. LP (57.5%), the PA group consuming significantly (P<0.05) more CHO than the PIA group (64.0 vs. 54.7%) across both phases. Within the PIA group, more (P<0.05) PRO was consumed in LP (16.3%) vs. FP (14.5%). More fat (P<0.05) was consumed by both groups in LP (28.2%) compared to FP (25.7%); although, the PIA group consumed more (P<0.05) fat than PA group (30.8 vs. 23.1%) across both phases. The results suggest that MC phase and physical activity level do influence the energy and macronutrient intake by young women.

Keywords

Energy; Food; Menstruation; Steroid hormones

Introduction

The human menstrual cycle is characterised as having two primary phases (follicular and luteal) during which the ovarian steroid hormones (oestrogens and progesterone) rise and fall dramatically. Previous research suggests that voluntary food intake in women varies with menstrual cycle phase [2,9,16,18,19,20,22,31] Voluntary food intake seems to be at its lowest in the late follicular phase (around ovulation), while in the luteal phase, the food intake appears greater than during the early follicular one.

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Several studies have attempted to link these fluctuations in food intake to the cyclic changes in the circulating ovarian steroid hormonal levels as discused by Moghissi *et al*. [23]. In particular, oestrogens have been shown to have an inhibitory effect on feeding behaviour in animals [7,8,27]. Conversely, progesterone has been shown to be an appetite stimulant [14]. Progesterone reaches maximum levels during the luteal phase in the menstrual cycle and this is also when food intake has been shown to increase in some women [2,9,16,18,20,22,31]. Although it is unclear whether food intake increases in the luteal phase can be attributed to elevated levels of progesterone or to the declining levels of oestrogen which occur in the latter part of the luteal phase [7,8,16,18,20]. A woman's energy balance may be affected by her menstrual cycle due to fluctuations in food intake [7,8,16,18,20], as well as variations in energy expenditure (e.g. physical activity level or other components) [5,28,34], The purpose of this study was to determine the energy intake during the course of one menstrual cycle and to detect possible differences between total energy intake and macronutrient consumption during the follicular and luteal phases in physically active and sedentary women.

Material and Methods

Physically active and inactive eumenorrheic female volunteers, aged 18 – 34 years, participated in the study. Each subject met the following criteria: regular menstrual cycles. 23 to 35 days long, absence of severe life stressors (death in the family, financial problems. etc.) or recent illness; no current or past (within the last 6 months) use of oral contraceptives; not currently on a weight-control diet; not engaged in excessive levels of physical activity (e.g. athletics) and a willingness to record food intake and basal temperature over the course of one complete menstrual cycle. After completing an informed consent and medical history form (which included the physical activity history), each subject answered a screening questionnaire regarding acceptability criteria and current levels of physical activity. Subjects also completed the Godin Leisure Time Exercise Questionnaire (for estimation of maximal oxy gen consumption (VO_2max) [1,15] and additional information in order to be classified as physically inactive (PIA) or physically active (PA). Subjects were classified as PA if they participated in regular strenuous exercise three or more times per week for approximately one year or longer. Subjects were considered PIA if they did not participate in regular physical activity or if any exercise they participated in required only minimal effort during the last year. Upon completion of all questionnaires, the body fat content was estimated in each subject by measuring thickness of 4 skinfolds: triceps, biceps, subscapular, and suprailiac. by using Lange skinfold calipers according to Durnin and Womersley [11].

Subjects were provided with log books to maintain accurate records of basal temperature and microtape recorders for reporting food intake for one complete menstrual cycle. In order to minimise the "learning effect" and ensure minimal errors in record keeping, each subject was educated by a registered dietitian during a training session regarding food portion estimation and equipment operation. Each subject completed a total of 6 weekly visits, lasting 0.5 to 1 h each. At every visit, the subjects submitted their records of daily activities. Occasional), follow-ups were made by phone to clarify data collection start dates, food intake information, and related matters.

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Morning basal temperature readings were taken during the same menstrual cycle as that of food data collection and used to determine the day of ovulation and thus the follicular and luteal phases of one menstrual cycle [23,32]. Dietary food records were analysed for daily energy (total kilocalories) and macronutrient (protein, fat. and carbohydrate) intake. using the Food Processor II (ESHA Research, Oregon. 1990) computerised dietary analysis program. In order to reduce intra-coder variation, one registered dietitian reviewed all assigned food codes and made decisions regarding food data entry. Macronutrient information, from foods consumed by subjects, that was not part of the original Food Processor II database (no-fat or reduced fat foods, etc.) was added to the database to enable more accurate dietary analysis. The source of this information were manufacturers' labels. Subjects were asked to maintain their regular activity patterns throughout the study. Compliance on this issue was monitored by occasionally having the subjects wear Caltrac motion sensor monitors and maintain daily activity record logs. This information was then compared to the responses from the physical activity history section of the medical history form, the initial screening questionnaire responses, and the Godin Leisure Time Exercise Questionnaire responses. Ten days of each menstrual cycle phase were pooled and then statistically analysed. The 10 days of luteal and follicular diet records were chosen to encompass the days around the midpoint of the respective phase which enabled comparisons of the results with those reported by others [2,18,22,25].

The data were subjected to the ANOVA for dependent variables and the post-hoc Tukey's test, the level of $P \leq 0.05$ being considered significant.

Results

Twenty-three out of 30 recruited subjects completed the study: 12 in the PA group and 11 in the PIA group. The remaining 7 subjects did not meet the selection criteria. The basic characteristics of the subjects are reported in Table 1. The subjects in both groups were found to maintain relatively constant daily activity patterns during the course of the study.

The results of the dietary analysis are reported in Table 2. There were no significant main or interactive effects (i.e. between groups or between menstrual cycle phases) for total energy intake while the PA group had a higher relative energy intake than the PIA group (34.2 and 27.8 $kca^{-1} \cdot day^{-1}$ respectively; $P<0.05$). both phases combined. The groups also differed significantly ($P<0.05$) with respect to the percent contribution of carbohydrates to the total energy intake, the PA and PIA groups consuming 64.0 and 54.7% of carbohydrates, respectively. Besides, the consumption of carbohydrates was significantly higher in the follicular than in the luteal phase (61.2 and 57.5%. respectively; $P<0.05$), both groups combined. The group×cycle phase interaction was not significant. The relative carbohydrate intake was significantly higher in the PA than in the PIA group (5.38 and 3.77 $g \cdot kg^{-1} \cdot day^{-1}$. respectively. $P<0.05$).

A significant group×cycle phase interaction was found for protein consumption. The post-hoc analysis revealed that the PI A group consumed a significantly higher percentage of protein in the luteal phase compared to the follicular phase or to the PA group in the luteal phase (see Table 2). There was no significant between-group difference for relative protein intake but a significant difference between cycle phases was found, the protein in-take being greater in the luteal phase than in the follicular one (1.17 and 1.09 g·kg^{-1} day^{-1}, respectively; $P<0.05$). The group×cycle phase interaction was not significant.

The PA group consumed less fat than did the PIA group (23.1 and 30.8%, respectively; $P<0.05$). The fat consumption was also higher in the luteal than in the follicular phase (28.2 and 25.7%. respectively; P<0.(05) and the same was true for the relative fat intake (0.98 and 0.88 g·kg^{-1} ‘day^{-1}, respectively; $P<0.05$). No significant interactions were found between groups vs. cycle phase.

Discussion

The tape-recorded food records revealed that the consumption of macronutrients by the eumenorrheicpossibly total energy intake) during the females fluctuated across the menstrual cycle. Furthermore, these fluctuations varied between PA- and PIA women. In previously published studies on primates [3,6–8,14,17,27], a significant effect of the menstrual cycle on food intake has been demonstrated. the energy intake being lowest at the time of ovulation, and higher in the luteal phase than in the follicular one. It is not completely certain, however, that the same effect exists in human beings. In this study no overall (both PA and PIA groups combined) significant differences in energy intake between both phases of the menstrual cycle have been found, which is in agreement with some authors [12,25,33]. although an increase in energy intake during the luteal phase was reported by others [2,13,16,20,22,26].

Unlike many other studies on the relationship between food intake and the menstrual cycle [2,9,10,12,18,19,22]. the present study was conducted using tape-recorded daily food repords prepared by subjects. It has been suggested that such a procedure improves the validity and reliability of the energy intake data [4,21,29].

As demonstrated in this study, the overall percentage of carbohydrate consumed in the follicular phase was significantly greater compared to the luteal phase. This finding is at variance with several studies [10,13,22,24] in which a greater carbohydrate intake was found during the luteal phase than in the follicular one. Other investigators [2,12,19,31], however, have found no such changes. The reason for a greater carbohydrate intake in the follicular phase is unclear but it may be related to the large variability in carbohydrate intake, between-study differences in dietary collection methodology, and/or varying lifestyle patterns of our PA subjects [19,31].

The overall relative protein intake (per kg body mass) found in this study was greater in the luteal phase compared to the follicular one. Furthermore, the PIA group consumed significantly more protein (% kcal/day) compared to the PA group in the luteal phase. Oram [24] and other researchers [13,19,22,31] are in agreement with these findings of greater protein intake during the luteal phase than in the follicular one. For both groups, the fat intake (% kcal/day) and relative fat intake (g/kg-bw/day) were greater in the luteal phase compared to the follicular one which was in agreement with several other studies [13,19,22,24,31] although other authors [10,25,30] found no effect of menstrual cycle phase on dietary fat consumption. This previously reported lack of such an effect could be related

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to whether or not subjects lived in environments that allowed access to a wide variety of foods. For example, American college students limited to on-campus dining, typically consume higher amounts of fast food (lower in carbohydrate, higher in fat and protein contents) [16,20,24] than people of a similar age living elsewhere. The subjects in the present study may be more typical for the general American population since they were not limited to dining hall experiences as were the subjects in previous studies [16,20,24].

The results of the present study indicate that there is a relationship between menstrual cycle phase, energy intake and macronutrient consumption. However, this relationship varies to some extent among the PA and the PIA women. The present findings suggest that when research is undertaken to study energy intake and/or macronutrient consumption by women, variables such as menstrual cycle phase should be a factor in the study design. Further research, involving hormonal measurements, is needed to find out if the trend of increased macronutrient intake (and possibly total energy intake) during the menstrual cycle is related to changing levels of oestrogen, to increasing levels of progesterone, or to an interaction of these two steroid hormones.

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Table 1

Mean characteristics (±SE) of subjects from the physically active (PA) and physically inactive (PIA) groups

Variable / Group	PA (n=12)	PIA (n=11)
Age (years)	22.1 ±0.9	22.6 ±1.3
Height (cm)	165.2 ±1.8	163.0 ±2.2
Weight-Start (kg)	58.0 ±1.9	66.7 ±4.5
Weight-End (kg)	58.1 ±2.1	66.6 ±4.7
Body Fat (%)	22.5 ±0.9	27.6 ±1.4
$\dot{V}O_2max$ (ml·kg^{-1}·min^{-1})	43.4 ±1.5	35.5 ±1.1
Exercise sessions (days/week)	03.4 ±0.2	00.4 ±0.2
Menstrual cycle (total days)	29.8 ±1.8	28.1 ±0.9
Follicular phase (days)	17.3 ±1.0	14.6 ±0.7
Luteal phase (days)	12.5 ±1.0	13.6 ±1.0

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Table 2

Dietary intakes (means ±SE) recorded in the physically active (PA, n=12) and physically inactive (PIA. n=l1) groups during 10 days of the luteal and follicular phases of menstrual cycles

Menstrual cycle phase	Luteal		Follicular	
Variable	**PA**	**PIA**	**PA**	**PIA**
Energy intake (kcal·day^{-1}) (kcal·kg^{-1}·day^{-1})	2037 ±150	1827 ±203	1901 ±124	1815 ±197
	35.32 ±2.49	27.81 ±2.69	33.13 ±2.32	27.70 ±2.61
Carbohydrate (%kcal·day^{-1}) (g·kg^{-1}·day^{-1})	62.5 ±3.10	52.6 ±2.91	65.4 ±3.1	56.9 ±2.8
	5.46 ±0.41	3.66 ±0.43	5.31 ±0.35	3.88 ±0.37
Protein (%kcal·day^{-1}) (g·kg^{-1}·day^{-1})	14.2 ±1.2	16.3 ±1.5	14.3 ±1.2	14.5 ±1.4
	1.25 ±0.13	1.11 ±0.13	1.18 ±0.12	1.00 ±0.13
Fat (%kcal·day^{-1}) (g·kg^{-1}·day^{-1})	24.6 ±2.9	31.8 ±2.5	21.6 ±2.8	29.8 ±2.3
	0.98 ±0.14	0.98 ±0.12	0.83 ±0.14	0.93 ±0.12