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Modest changes in dietary intake across the menstrual cycle: implications for food intake research

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Food intake varies across the menstrual cycle in mammals, energy intake usually being greater in the premenstrual phase compared with the postmenstrual phase. Premenstrual increments in energy intake and a preferential selection of carbohydrate have been suggested to be greater in women with premenstrual syndrome (PMS), who may be more sensitive to cyclical hormonal or neurotransmitter fluctuations. This has direct implications for research within populations of women, especially where the primary outcome is diet or a change in energy balance. We aimed to determine whether: the premenstrual intake of energy and macronutrients differed from the postmenstrual intake; the change in intake across the menstrual cycle differed in women with PMS compared with controls; and the change in intake was related to the severity of premenstrual symptoms. We collected 3 d dietary intake data during the postmenstrual and premenstrual phases of the menstrual cycle in thirty-one women with PMS and twenty-seven control women. The consumption of energy and macronutrient intake were similar between the phases of the cycle in women with PMS. Conversely, intakes were usually greater premenstrually in control women, although not all differences were statistically significant. Exceptions were with non-milk extrinsic sugars and alcohol, which were both consumed in greater amounts in the premenstrual phase in women with PMS. Significant correlations were observed between the severity of symptoms and the change in the consumption of these nutrients. These data suggest that a consideration of the menstrual cycle phase and PMS in diet may not be warranted, especially in cross-sectional analysis, although it may need to be taken into account when examining change in intake during dietary interventions.

Food intake: Premenstrual syndrome: Menstrual cycle: Diet

Cyclical variations in energy and macronutrient intake have been observed in previous studies (Dye & Blundell, 1997). Total energy intake has been shown to vary during the menstrual cycle, the highest intakes usually being observed premenstrually (luteal phase). This phenomenon has been demonstrated both in primates (Gilbert & Gillman, 1956; Rosenblatt *et al.* 1980) and in human studies (Buffenstein *et al.* 1995; Dye & Blundell, 1997; Li *et al.* 1999; Reimer *et al.* 2005) but is not seen in women using hormonal preparations (Krakow, 1992), those with anovulatory cycles (Barr *et al.* 1995) and highly restrained eaters (Schweiger *et al.* 1992). This has direct implications for food intake and appetite research, and implies that cycle phase should be considered in studies that assess female participants.

The variation in dietary intake across the menstrual cycle may be accentuated in women who experience physiological and psychological symptoms that indicate they are in the premenstrual phase. If this were true, women with premenstrual syndrome (PMS) would be expected to have a greater increase in energy intake between the follicular and luteal phases compared with women without symptoms.

PMS comprises a cluster of behavioural, somatic and affective symptoms of varying severity that occur in the 7–10 d prior to the onset of menstruation and that are relieved at or shortly after commencement of the menstrual flow. Although more than 200 symptoms have been associated with PMS, the symptoms that classically characterise the syndrome include depression, irritability, mood swings, breast tenderness, bloating, changes in appetite and food cravings (Freeman, 2003). These latter symptoms in particular have promoted the belief that premenstrual energy intake is greater in women with PMS. However, no cyclical variation in food intake or macronutrient selection is consistently demonstrated in women with PMS. Evidence from a limited amount of research has found similar premenstrual energy increases in control women without PMS (Gallant *et al.* 1987; Wurtman *et al.* 1989; Cross *et al.* 2001). An improved understanding of the cyclical variation in dietary intake (and the possible differential effects in women with and without PMS) is important for researchers examining data from populations of women, especially those in whom diet or a change in energy balance is a primary outcome.

Abbreviations: NMES, non-milk extrinsic sugars; PMS, premenstrual syndrome.

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The primary aim of the present study was to prospectively examine energy and macronutrient intake premenstrually and postmenstrually in women with PMS and asymptomatic controls. Our hypotheses were: that premenstrual energy intake would be greater than postmenstrual intake, and that this difference would be exaggerated in women with PMS compared with controls; and that the increased intake of energy would be reflected in a greater consumption of fat and carbohydrate. A secondary aim was to determine whether the severity of premenstrual symptoms was associated with a change in energy and macronutrient intake. We hypothesised that greater symptom severity would result in a larger positive change in energy, fat and carbohydrate intake.

Methods

Participants

This study utilised data from women who had participated in three studies examining diet and menstrual health within the Human Appetite Research Unit at the University of Leeds, UK (Bryant *et al.* 2005). A total of seventy-three women responded to advertisements to take part in menstrual health research and met the eligibility requirements. The eligibility criteria were: age 18–47 years; regular menstrual periods; not using hormonal preparations (including oral contraception); an absence of clinical depression; not taking prescribed or over-the-counter medicine; not being on a weight-loss diet; not taking nutritional supplements. The recruitment and data collection procedures were identical in each study, and each was similar in terms of seasonality. After excluding women with missing data on dietary intake (*n* 4), menstrual symptoms (*n* 2), age (*n* 2) and BMI (*n* 6), as well as one participant with outlying dietary intake data, the final analysis data included fifty-eight women who had fully completed at least one menstrual cycle of symptom and dietary intake data collection.

Women were asked to self-report during recruitment whether or not they considered themselves to have PMS. This was originally used to form PMS and control groups; however, since measures were identical in each group, a prospective analysis of symptoms for one complete cycle during the study was used to confirm the presence or absence of PMS at the end of data collection.

Measures

Demographic and health information was collected on all women who came to the Human Appetite Research Unit. During this visit, women completed baseline questionnaires of self-reported cigarette smoking status (current, former, never), the number of units of alcohol consumed per week, the number of days per week on which exercise was taken, and the cycle length of the two previous menstrual cycles. Women were also given diaries to record symptoms and dietary intake prospectively during their next menstrual cycle. Dietary restraint, emotional eating and external eating behaviour were measured in two studies (thirty-seven women) using the Dutch Eating Behaviour Questionnaire (VanStrien *et al.* 1986).

Body weight was measured to the nearest 0·1 kg using a calibrated digital scale (Adam Equipment Company Ltd, Milton Keynes, UK). Height was measured to the nearest 0·1 cm without shoes using a metal rule attached to a wall and a standard triangular headboard using a vertical ruler. These measurements were made by trained personnel during the visit. BMI was calculated as weight in kilograms divided by height in metres squared.

Symptoms were measured daily using the Daily Symptoms Report (Freeman *et al.* 1996) for one complete menstrual cycle. This was the primary tool for the diagnosis and assessment of PMS. It is a well-validated, single-page, self-report questionnaire comprising seventeen symptoms rated on a 5-point Likert scale (0 = not present at all; 4 = severe), which form the symptom clusters of mood, behaviour, pain and physical symptoms. Women were asked to rate the presence and severity of these commonly reported premenstrual symptoms every evening in the Daily Symptoms Report. They were asked to begin recording their symptoms in the Report every evening on a daily basis from the first day of menses following recruitment, until the start of the next menstrual cycle. Diaries were returned weekly using freepost envelopes to prevent the identification of patterns of symptoms and reduce the likelihood of demand characteristics producing stereotypical patterns of reporting. Based on criteria set by the NIMH workshop (National Institute of Mental Health, 1983), women were categorised as having PMS if their total premenstrual symptom severity score was greater than 6 and at least 30 % greater than the score in the postmenstrual phase. The remaining participants were categorised as controls. Written informed consent was obtained from each participant, and the study was approved by the Institute of Psychological Sciences, University of Leeds Research Ethics Committee.

Diet was assessed using two 3 d food diaries based on estimates of household measures (i.e. not based on weighed intakes). Participants were told to contact the researcher on day 1 (i.e. first day of menses) so that their cycle phase could be monitored and the timing of food intake recording could be accurately determined. All participants were instructed to record their consumption of food and drink for days 4, 5 and 6 (phase 2, postmenstrual) of the menstrual cycle and days −6, −5 and −4 (phase 4, premenstrual) based on their usual cycle length and the timing of the previous two cycles (retrospectively reported). Participants were given both verbal and written instructions on how to complete the food diaries. They were asked to contact the researcher again on the first day of menses of the next menstrual cycle when accurate phase identification was confirmed.

Dietary records were reported dependent on the day of menstrual cycle and were therefore non-systematically distributed across days of the week. Nutrient analysis was performed using Diet5 for Windows (Univation Ltd, Aberdeen, Scotland) analysis program. The dietary outcomes examined were total energy, total macronutrients (carbohydrate, fat, protein, non-milk extrinsic sugars (NMES), non-starch polysaccharides) and percentage energy from carbohydrate, fat and protein at phase 2 and phase 4.

The Mifflin–St Jeor equation (Mifflin *et al.* 1990; Frankenfield *et al.* 2005) was used to estimate BMR:

$$\text{BMR} = 10 \times \text{weight (kg)} + 6{\cdot}25 \times \text{height (cm)} - 5 \times \text{age (years)} - 161.$$

We chose a conservative activity factor of 1·375 for light activity based on the reported number of days on which participants exercised; therefore, the estimated total daily caloric need for the participants was calculated as BMR × 1·375. This assumes that the participants had a stable weight. In order to estimate the degree of accuracy of dietary reporting (Mifflin *et al.* 1990; Frankenfield *et al.* 2005), the ratio of energy intake to BMR was calculated.

Statistical analysis

Variables that were chosen *a priori* for inclusion in regression models included age and BMI. Additional variables that were examined to determine whether they influenced the association between group (PMS or control) and change in dietary intake (phases 2 *v.* 4) were cigarette smoking status, consumption of alcoholic beverages, exercise and dietary restraint. None of these variables influenced the association (although dietary restraint was available for only thirty-seven out of the possible fifty-eight subjects); therefore, the final full models included age and BMI. Data were analysed using SAS software version 9.1 (SAS Institute Inc, Cary, NC, USA).

In order to determine whether the premenstrual intake of energy and macronutrients differed from the postmenstrual intake, we created a 'stacked' dataset, such that every study participant provided two observations (postmenstrual, premenstrual). Repeated-measures regression (PROC GENMOD) was used with the LSMEANS option to estimate and compare the age- and BMI-adjusted mean nutrient intake during the postmenstrual and premenstrual phases of the menstrual cycle. Separate models were run for women with PMS and controls.

In order to compare whether changes in energy and macronutrient intake differed between women with PMS and controls we used linear regression models (PROC GENMOD) with the LSMEANS option. Change in dietary intake (change score) was calculated as the difference between the postmenstrual (phase 2) and premenstrual (phase 4) phases of the menstrual cycle, such that negative change scores represented a lower dietary intake during the premenstrual phase. All models were adjusted for age and BMI.

Pearson's partial correlation coefficients were calculated to examine whether the severity of premenstrual symptoms was correlated with the change in nutrient intake between the postmenstrual and premenstrual phases of the menstrual cycle separately in women with PMS and controls.

Results

We found no significant differences between women with and without PMS for any of the demographic characteristics examined (Table 1). Women with PMS and controls were on average 34 years of age and of normal weight, consumed 5–6 units of alcohol per week, exercised about three times per week, and most likely never smoked cigarettes. Ratios of energy intake to BMR were between 0·9 and 1·0. Assuming that body weight was stable and that activity levels were light, this is indicative of a reasonably plausible reported dietary intake. Mean cycle lengths were 28 and 30 d for women with PMS and controls, respectively. The average day on which the women began recording their premenstrual food diary was −7 and −5·9 (before menstruation) for women with PMS and controls, respectively. We found no difference between the groups in the number of weekend days on which dietary intake was recorded for either phase. In general, both groups scored within the moderate range for dietary restraint, emotional eating and external eating (mean scores 2·4–3·1).

Table 1. Demographics characteristics in women with premenstrual syndrome (PMS) and controls

	PMS (*n* 31)		Controls (*n* 27)	
	Mean	SD	Mean	SD
Age (years)	34·5	5·4	34·0	7·7
BMI (kg/m^2)	23·8	4·2	23·1	3·1
Alcohol (units/week)	5·2	4·8	6·1	5·4
Smoking (%)				
Current	6·5		11·1	
Former	29·0		25·9	
Never	64·5		63·0	
Exercise (days/week)	3·6	2·1	2·8	1·9
EI:BMR				
Phase 2	0·9	0·2	1·0	0·3
Phase 4	1·0	0·2	0·9	0·2
Cycle length (d)	28·0	3·4	29·9	11·4
First day of premenstrual dietary intake (day)	−7·0	3·3	−5·9	3·7
Recorded number of weekend days of dietary intake (%)				
Phase 2				
0 weekend days	53·6		39·1	
1 weekend day	17·9		26·1	
2 weekend days	28·6		34·8	
Phase 4				
0 weekend days	58·1		42·3	
1 weekend day	22·6		30·8	
2 weekend days	19·4		26·9	
Total symptom severity score				
Phase 2	4·0	3·8	5·0	5·2
Phase 4	14·1	8·7	5·5	4·6*
Eating behaviour				
Dietary restraint	2·7	0·8	2·8	1·0
Emotional eating	2·7	0·7	2·8	0·7
External eating	3·0	0·6	3·1	0·7

PMS was defined as total symptom score greater than 6 and an at least 30 % increase in symptoms premenstrually compared with postmenstrually.
EI:BMR, ratio of energy intake to BMR; calculated using Miffin–St Jeor equations based on light activity.
* Premenstrual symptoms were significantly greater in the PMS group compared with the control group: $P<0·05$.

Comparisons between postmenstrual and premenstrual nutrient intake by group are shown in Table 2. Women with PMS consumed slightly fewer kilojoules during the premenstrual phase (8286 kJ, 95 % CI 7667, 8906) compared with the postmenstrual phase (8381 kJ, 95 % CI 7861, 8902). In contrast, control women consumed more energy during the premenstrual phase than the postmenstrual phase (8577 kJ, 95 % CI 7881, 9272; 8169 kJ, 95 % CI 7427, 8907, respectively). Differences were not significant between cycle phases for women with PMS or controls. Similar patterns were found for total fat, carbohydrate, protein, non-starch polysaccharides and percentage energy from protein; that is, compared with the postmenstrual phase, premenstrual intakes were similar for the PMS group but higher for the control women. Conversely, women with PMS consumed more NMES and alcohol, and a percentage of energy from fat, during the premenstrual phase compared with the postmenstrual phase.

Table 2. Age- and BMI-adjusted mean energy and macronutrient intake in women during the postmenstrual (phase 2) and premenstrual (phase 4) phases of the menstrual cycle in women with premenstrual syndrome (PMS) compared with controls

		Postmenstrual phase (phase 2)		Premenstrual phase (phase 4)	
Daily intake	Group	Mean	95 % CI	Mean	95 % CI
Energy (kJ)	PMS	8381	7861, 8902	8286	7667, 8906
	Control	8169	7427, 8907	8577	7881, 9272
Fat (g)	PMS	84	76, 91	84	76, 92
	Control	75	66, 85	82	74, 90
Carbohydrates (g)	PMS	232	215, 249	229	207, 251
	Control	240	215, 264	249	223, 275
Protein (g)	PMS	77	69, 84	73	67, 78
	Control	70	63, 78	74	67, 81
Non-milk extrinsic sugar (g)	PMS	63	54, 72	65	56, 75
	Control	69	58, 79	73	62, 83
Non-starch polysaccharides (g)	PMS	13	11, 15	13	11, 15
	Control	14	12, 15	15	12, 17
Alcohol (g)	PMS	9	5, 12	10	6, 15
	Control	12	7, 17	11	6, 16
% Fat	PMS	37	35, 39	38	36, 40
	Control	34	32, 37	36	34, 38
% Carbohydrates	PMS	47	44, 49	46	44, 49
	Control	50	46, 53	48	46, 51
% Protein	PMS	15	14, 17	15	14, 16
	Control	14	14, 15	15	14, 16

PMS was defined as total symptom score greater than 6 and an at least 30 % increase in symptoms premenstrually compared with postmenstrually.

Again, differences between cycle phases for these nutrients were not significant.

We also examined (data not shown) whether nutrient intake differed between the PMS and control groups during the postmenstrual phase and the premenstrual phase and found no significant differences between the groups. During the postmenstrual phase (phase 2), women with PMS tended to have higher mean values for total energy, total fat, total protein, percentage energy from fat and percentage energy from protein compared with women in the control group. The inverse relationship was generally found during the premenstrual phase (phase 4).

Change scores for the difference between dietary intakes in phase 4 compared with phase 2 are shown in Table 3. For all nutrients, except alcohol and percentage energy from protein, change values were positive in control women (i.e. consumption was higher premenstrually than postmenstrually). Conversely, the majority of change values for women with PMS were negative except for fat, NMES, alcohol and percentage energy from fat. Change in consumption did not differ between women with PMS and control women for any nutrient.

Correlations between change in nutrient intake and symptom severity are shown in Table 4. It is important to remember that change scores can be positive or negative. Thus, this test tells us whether symptom severity is related to the degree of dietary change, independent of the direction of change (i.e. whether it is reduced or increased). For example, positive associations between change and symptoms could be found

Table 3. Age- and BMI-adjusted mean change in energy and macronutrient intake between the postmenstrual (phase 2) and premenstrual (phase 4) phases of menstrual cycle in women with premenstrual syndrome (PMS) compared with controls

	PMS		Controls	
	Mean Δ	95 % CI	Mean Δ	95 % CI
Energy (kJ)	−107	−683, 468	424	−193, 1041
Fat (g)	0·4	−8·8, 9·7	7·1	−2·8, 17·0
Carbohydrates (g)	−3·4	−22·1, 15·3	10·1	−9·9, 30·2
Protein (g)	−3·8	−11·0, 3·5	4·1	−3·7, 11·8
Non-milk extrinsic sugar (g)	2·3	−7·3, 11·8	3·7	−6·6, 14·0
Non-starch polysaccharides (g)	−0·0	−1·4, 1·4	1·1	−0·4, 2·6
Alcohol (g)	1·7	−2·3, 5·8	−1·4	−5·4, 3·1
% Fat	0·8	−2·0, 3·6	1·8	−1·2, 4·8
% Carbohydrates	−0·5	−3·7, 2·7	−1·1	−4·5, 2·3
% Protein	−0·3	−1·5, 0·8	0·1	−1·1, 1·4

PMS was defined as total symptom score greater than 6 and an at least 30 % increase in symptoms premenstrually compared with postmenstrually.

Table 4. Pearson partial correlation between premenstrual symptom severity and change in nutrient intake between the postmenstrual (phase 2) and premenstrual (phase 4) phases of the menstrual cycle

	Mood symptoms		Behaviour symptoms		Pain symptoms		Physical symptoms		Total symptoms	
Change in nutrient intake	PMS	Controls	PMS	Control	PMS	Controls	PMS	Controls	PMS	Controls
Energy (kJ)	−0·02	0·01	−0·13	−0·20	−0·32	−0·05	−0·29	0·18	−0·18	−0·06
Fat (g)	−0·19	−0·10	−0·23	−0·28	−0·23	−0·08	−0·35	0·14	−0·28	−0·15
Carbohydrates (g)	0·02	0·13	−0·16	0·12	−0·47	0·03	−0·22	0·16	−0·19	0·14
Protein (g)	0·05	0·00	0·08	−0·32	−0·09	−0·07	−0·03	0·09	0·03	−0·12
Non-milk extrinsic sugar (g)	−0·09	0·32	−0·21	0·31	−0·43*	0·17	−0·21	0·40*	−0·24	0·37
Non-starch polysaccharides (g)	−0·22	0·08	−0·27	−0·07	−0·33	0·04	−0·38*	−0·37	−0·32	−0·04
Alcohol (g)	0·15	0·31	0·18	0·13	0·45*	0·03	0·17	0·19	0·25	0·23
% Fat	−0·20	−0·24	−0·14	−0·32	−0·00	−0·20	−0·23	0·02	−0·17	−0·27
% Carbohydrates	0·01	0·17	−0·16	0·42*	−0·36	0·19	−0·04	0·01	−0·14	0·28
% Protein	0·11	0·05	0·24	−0·17	0·19	−0·01	0·21	0·01	0·22	−0·04

PMS, premenstrual syndrome.
Significant correlation: *$P<0·05$.

with a greater negative or positive change in dietary intake. In women with PMS, change in nutrient intake was associated with pain symptoms for NMES ($r=-0·43$, $P<0·05$) and alcohol ($r=0·45$, $P<0·05$). This means that a greater change in intake of NMES was associated with lesser symptoms in that group (although still meeting the criteria for PMS); and that an increased change in alcohol consumption during the premenstrual phase compared with the postmenstrual phase was associated with higher symptom severity. As we know that the women with PMS consumed more NMES and alcohol premenstrually, we deduce that this change was positive. The only other significant correlation in women with PMS occurred with physical symptoms and change in consumption of non-starch polysaccharides ($r=-0·38$, $P<0·05$). The change score for this nutrient was negative but negligible.

In control women, significant correlations were only found between premenstrual physical symptoms and change in the consumption of NMES ($r=0·40$, $P<0·05$). This means that a greater change in intake of NMES during the premenstrual phased compared with the postmenstrual phase was associated with greater premenstrual symptom severity. As we know that our control women had a positive change for NMES (Table 4), we know that this change was positive.

Discussion

Women with PMS are reported to be more sensitive to hormonal or neurotransmitter fluctuations (Bancroft *et al.* 1991; Wurtman & Wurtman, 1995). As a dysphoric mood is often associated with weight gain (Istvan *et al.* 1992; Carpenter *et al.* 2000; Heo *et al.* 2006), and a major symptom of PMS is increased appetite, we hypothesised that women with PMS would show a greater increase in energy and macronutrients in the premenstrual phase compared with control women. This hypothesis was not, however, supported by our data. In fact, for the majority of nutrients, women with PMS consumed a similar, if not lower, amount in the premenstrual phase compared with the postmenstrual phase of the menstrual cycle. Furthermore, correlations and change scores tended to be negative in women with PMS (i.e. reduced premenstrual compared with postmenstrual intake) and positive in control women.

The consumption of nutrients did not differ significantly between groups or cycle phases, although dietary intake appeared to be more stable across the postmenstrual and premenstrual phases in women with PMS, with lower change values for the majority of nutrients in women with PMS compared with controls. Thus, only women in our control group reported a pattern of energy and macronutrients intake across the menstrual cycle that was consistent with the literature (i.e. increased consumption in the premenstrual phase) (Dalvit-McPhillips, 1983; Brzezinski *et al.* 1990; Cross *et al.* 2001; Reimer *et al.* 2005).

While the difference in dietary intake between phases was not statistically significant, it may be considered to be clinically meaningful. Control women consumed approximately 419 kJ/d (100 kcal/d) more in the premenstrual phase. A sustained intake of this extra amount of energy would result in a gain of approximately 5 kg in body weight over 12 months (assuming that all other variables were constant). However, the average energy intake for both phases was 8372 kJ (approximately 2000 kcal), close to the estimated average requirement for women of this age. Thus, the reduction in calories that was observed during the postmenstrual phase appeared to compensate for the rise in intake premenstrually (whether or not this was conscious).

Previous research that has examined the variation in energy across the menstrual cycle has not usually differentiated between women with and without PMS. That which has reports inconsistent results. We know of two studies (Wurtman *et al.* 1989; Cross *et al.* 2001) that have reported higher premenstrual energy intake. Wurtman *et al.* (1989) reported a greater consumption of energy in the premenstrual phase in both women with and without PMS, although differences between the cycle phases were only significant in women with PMS. This study was, however, small, with only nine women in the PMS group.

Cross *et al.* (2001), on the other hand, recruited eighty-eight women with PMS and forty controls, comparable with the current study. This study was well designed and found an increase in premenstrual intake of energy and all macronutrients with PMS. Control women also reported a rise in energy

and fat intake, but all other macronutrients and NMES were similar between the phases. One major difference between this study and our study was that Cross and co-workers recruited only women who were overweight. The authors applied Goldberg's cut-off limits to exclude women with energy intakes that were incompatible with energy requirements. However, this equation assumes that people are not currently losing or gaining weight (Margetts & Nelson, 1991). Given that overweight women are most likely to underreport their energy intake (Plankey *et al.* 1997), it is possible that women in the Cross *et al*. (2001) study did not accurately report their dietary intake.

Gallant *et al.* (1987) observed trends that were similar to those observed in our study, whereby a premenstrual rise in energy intake was demonstrated only in control women, and intakes were not significantly different from those of women with PMS. Energy and macronutrient intake were examined in just nine women with PMS and nine controls, so power may not have been adequate. On the basis of the currently available evidence, there are few data to suggest that a change in dietary intake across the menstrual cycle is exaggerated in women with PMS.

Dietary intake that is affected by menstrual cycle phase could influence within-person variation. However, provided that dietary data are collected independent of the menstrual cycle, the error caused by within-person and between-person variation should be random. It would be more useful to assess menstrual cycle phase as a potential confounder in studies that are assessing change in dietary intake, particularly for dietary intervention research. In this scenario, the phase of the menstrual cycle may affect the precision and accuracy of the data. For example, a controlled intervention that has been designed to alter diet will usually look for, and consider meaningful, differences in intake that are of the order of those seen across the phases of the menstrual cycle in the present study (i.e. 420–840 kJ/d (100–200 kcal/d)), which over a period of sufficient duration would lead to weight change. Thus, the results might depend on whether the study groups are similar in terms of the menstrual cycle phase in which dietary data are collected.

We determined cycle phase by self-report rather than by measuring circulating hormones. There is some evidence that women with anovulatory cycles do not show fluctuations in energy intake (Dye & Blundell, 1997). As we did not assess ovulation by temperature or hormones, we cannot be certain that all cycles were ovulatory. Food intake was reported by participants from days 4 to 6 of the menstrual cycle, which was easily identified and most reliably associated with low levels of circulating hormones (Vander *et al.* 1998). Premenstrual intakes were, however, reported based on an estimated date of next menstruation and were confirmed prospectively. It is possible that the premenstrual food diaries could have been collected outside the premenstrual phase. We therefore re-examined our findings using only the data from forty-four women (nineteen controls and twenty-five women with PMS) who had a verified premenstrual phase food intake data; the results did not differ for any of the analyses.

All research that assesses nutrient intake suffers from error associated with the latter's measurement. Difficulties involved in accurate, unbiased assessment of the diet are well known to nutrition researchers, and there is little doubt that measurement is subjected to bias that prevents the disclosure of valid habitual estimates of food intake (Beaton, 1994; Willett, 1998). Any bias in reporting should, however, be similar between the PMS and control groups. Reports of food intake could have been affected by participant motivation and reliability. Intakes were dependent upon self-reported data, which are open to potential underreporting (Smith *et al.* 1989; Klesges *et al.* 1995; Livingstone, 1995; Willett, 1998).

Participants are usually more highly motivated at the beginning of data collection, and later intakes may therefore not be a true reflection of habitual intake, whereas earlier reports of intake may be affected by social desirability (Nelson *et al.* 1989). It is therefore possible that the two food diaries were completed differently because of order effects; the first diaries were completed shortly after menses so one would anticipate greater attrition (and lower intake) premenstrually, which was not found.

We asked our participants to complete 3 d food diaries instead of 7 d diaries because of the total period of time that other data, for example symptom diaries, were being collected (an average menstrual cycle being 28 d). Evidence of the number of days that are required to estimate nutrient intake with good accuracy is variable, although 2–6 d have been suggested (Palaniappan *et al.* 2003). Primarily, our decision to use 3 d diaries was based on the practicality of assessing diet twice within one menstrual cycle. The completion of 3 d diaries allowed a greater number of days between reporting, which we hypothesised would reduce the fatigue effects of detailed dietary intake recording and thereby minimise the risk of underestimation of energy intake; we acknowledge, however, that there is currently a lack of consensus regarding how different methods affect the accuracy and completeness of dietary intake reporting. More decisively, the completion of 7 d food diaries would have encompassed more than one cycle phase (e.g. postmenstrual phase 2 lasted 5 d). We maintained close contact with all participants, and the importance of accuracy was strongly expressed to each participant, although there is no evidence that this improves the accuracy of reporting.

As a change in energy intake between the two cycle phases was usually positive in controls and negative in women with PMS, there does not seem to have been a systematic increase in reporting fatigue, which could influence dietary intake unless these groups responded differently. A counterbalanced design, whereby participants would have been randomised to record either the premenstrual or the postmenstrual phase first, would have reduced reporting bias.

In summary, we found that women with PMS did not increase their consumption of energy or macronutrients in the premenstrual phase of the menstrual cycle. Women in the control group ate in a way that reflected their underlying hormonal state (i.e. intakes were greatest in the premenstrual phase), and our findings are similar to those of previous human and animal research (Buffenstein *et al.* 1995; Dye & Blundell, 1997). However, any differences between cycle phase or group were not of sufficient magnitude with this sample size to reach statistical significance. This has some implications for nutrient and food intake research, such that dietary researchers may not need to measure cycle phase and/or severity of PMS. We believe that natural small fluctuations that are compensated with a subsequent lowering of

energy intake in the postmenstrual phase will not affect diet study outcomes. We recommend, however, that research examining a change in dietary intake in populations of women consider the stage of the menstrual cycle and PMS, particularly if the primary outcome is dietary from dietary intervention research.

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