

Research Article

Intake of dietary soy isoflavones in relation to perimenstrual symptoms of Korean women living in the USA

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Abstract

This study was conducted to identify the potential relationship between the dietary intake level of soy isoflavones and perimenstrual symptomatology. The research design was a cross-sectional study. The sample was made up of 84 Korean women living in the USA, aged 28–40 years. The Moos Menstrual Distress Questionnaire (MDQ) and the Food Frequency Questionnaire were used as measurement tools. The soy isoflavone intake was significantly correlated with MDQ scores in the menstrual phase. In conclusion, the beneficial effect of dietary soy isoflavones on certain menstrual symptoms was established, suggesting that soy isoflavones could be one of the dietary factors related to the complexity of premenstrual syndrome (PMS). The positive effect of soy isoflavones on PMS warrants further study.

Key words

isoflavones, Korean, Moos Menstrual Distress Questionnaire, premenstrual syndrome, soy.

INTRODUCTION

Premenstrual syndrome (PMS) and menstrual distress are unique to women of reproductive age. As the temporal fluctuation in symptoms is tightly linked with the menstrual cycle, prior research has suggested that such fluctuations might be the result of a complex interaction between ovarian steroids and central neurotransmitters (Mortola, 1998). Premenstrual symptoms occur in 95% of all women of reproductive age, with 5% of those women suffering from PMS (Ismail & O'Brien, 2000).

Jefferson (2003) explained that non-pharmacological interventions, such as a healthy balanced diet, should be emphasized before resorting to pharmacological treatment as it helps lessen the symptoms of PMS and menopause. The consumption of a healthy balanced diet rich in unrefined carbohydrates and lean protein foods, low in fats (particularly saturated fats), and containing a wide variety of fruits and vegetables should be the goal of every woman. For women with milder forms of PMS, nutritional management might be a preferred alternative to pharmacological treatments (Freeman *et al.*, 2003). Dietary modification as a treatment for PMS has involved recommendations for foods rich in grains, vegetables, vitamins, and minerals but low in fat, sodium, caffeine, and alcohol (Bussell, 1998; Ismail & O'Brien, 2000;

Bosarge, 2003; Halbreich, 2003). Bussell (2000) suggested the main aim of a dietary change is to reduce circulating estrogen and to block its attachment to receptor sites, as well as to increase serotonin synthesis. One such recommendation is to increase soy intake as phytoestrogens bind to estrogen sites, thereby decreasing the effects of estrogen.

Prior research has shown that dietary isoflavones can modulate endocrine status and influence ovarian cyclicity (Kenneth *et al.*, 1999). Isoflavones are a class of phytoestrogens found predominantly in legumes and beans. Soybeans are a rich source of isoflavones (Vincent & Fitzpatrick, 2000). Isoflavones can be found in some 300 plants, but are particularly abundant in soy (Marchelle, 1999). Interest in the role of dietary phytoestrogens and their effects on women's health has dramatically increased over the past decade. In particular, isoflavone-rich soy foods are now believed to play a role in alleviating the symptoms of menopause, maintaining bone density, reducing cholesterol levels, and protecting antioxidant activities (Jefferson, 2003). Although these effects have been significant concerning menopause, very few benefits of isoflavones have been reported with regard to PMS symptomatology (Washburn *et al.*, 1999; Vincent & Fitzpatrick, 2000).

EFFECTS OF ISOFLAVONES ON THE MENSTRUAL CYCLE

Studies in rats demonstrate that when phytoestrogens are administered in doses comparable to dietary levels, they can induce dramatic uterine growth in a dose-dependent and

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duration-dependent fashion, suggesting an action at the estrogen receptor site (Whitten *et al.*, 1992). Others have suggested that high-soy diets might lower the levels of bioavailable circulating steroids by raising sex hormone-binding globulin concentrations, as well as suppressing luteinizing hormone (LH) (Baker *et al.*, 2000).

The consumption of soy isoflavones can influence a woman's menstrual cycle experience, as well as affect the estrogen metabolism in premenopausal women. Several studies have demonstrated the possible effects of dietary intervention. For 6 months, Cassidy *et al.* (1994) gave 69 g of soy protein (45 mg isoflavones) daily to six western women. They found that the follicular phase increased by an average of 2.5 days ($P < 0.01$). This effect was associated with the suppression of the mid-cycle surges of follicular stimulating hormone and LH, suggesting an action at the hypothalamic-pituitary level. Lu *et al.* (1996) reported that, in premenopausal women, an intake of 960 ml of soy milk/day (≈ 200 mg of isoflavones) resulted in a 31–81% drop in circulating estradiol, dependent upon the specific time period in the menstrual cycle. Barnard *et al.* (2000) demonstrated that a low-fat, vegetarian diet could reduce dysmenorrhea and premenstrual symptoms, in association with an increase in serum sex hormone-binding globulin concentration, perhaps reducing estrogen activity. Watanabe *et al.* (2000) studied the effects of an isoflavone supplement on the hormonal states of young premenopausal women, observing that menstruation was prolonged in 60% of the women but reduced in 20%. In blood analysis, 17 beta estradiols were found to be suppressed throughout the menstrual cycle, while serum hemoglobin-binding globulin was significantly increased by $\approx 10\%$.

A growing body of laboratory and clinical evidence suggests that dietary isoflavones might exert their activity in the menstrual cycle; however, there is little work relating isoflavones' effects on menstrual cycle-related symptoms.

PURPOSE

To overcome the risk of protein deficiency resulting from a rice-based diet, Koreans traditionally have consumed high quantities of soybeans and soy foods (Kim *et al.*, 1998). The approximate dietary isoflavone intake of members of the Korean population has been estimated to be ≈ 15 mg day⁻¹ (Kim & Kwon, 2001), with soybeans and three traditional soy foods (tofu, soybean paste, soybean sprouts) composing > 94% of the total isoflavone intake. It is postulated that such a diet could influence the ovarian menstrual cycle and, in turn, potentially influence menstruation-related problems. As a way to further understand the dietary factors related to menstrual cycle symptomatology, this study explored the relationship between perimenstrual symptoms and the dietary intake level of soy isoflavones among Korean women living in the USA.

METHODS

A descriptive survey design was utilized to collect cross-sectional and retrospective data. Data analysis procedures included descriptive analysis, ANOVA, Pearson's correlation

coefficient, and stepwise regression using the SPSS computer program (version 10; SPSS, Chicago, IL, USA).

Sample

A convenience sample of 102 Korean women living in an urban area of south-eastern Michigan was recruited to participate in the study. Women were included if they: (i) were between 18 and 45 years of age; (ii) had regular menstrual cycles; and (iii) could understand and write either Korean or English. Individuals were excluded from the study if they were: (i) pregnant and/or lactating; (ii) taking medication for psychiatric or medical treatment; (iii) experiencing a major gynecologic disorder (i.e. endometriosis or menorrhagia); or (iv) following a special diet (i.e. weight loss, vegetarian, or therapeutic). Women were excluded from the present analysis if they did not complete the Food Frequency Questionnaire (FFQ), reducing the total sample size by 18 women. The final sample size for the present analysis was thus 84.

Data collection procedure

The research protocol was approved by the University of Michigan Health Sciences Institutional Review Board and data were collected from April–July 2002. Access to the study's participants was accomplished through assistance from the leaders of Korean community organizations and churches. Flyers describing the project also were posted in Korean grocery stores. Community leaders were asked to make the initial contact with potential participants, briefly explaining the study to them and obtaining verbal permission for contact by the researchers. The principal investigator then contacted each woman by phone or email to make an appointment at her home or church. During the visit, subjects read and signed an informed consent form agreeing to participate in the study. Each participant received a small gift (\$US2) as a token of appreciation for her participation.

The women spent ≈ 30 min completing a questionnaire regarding their demographics and general menstrual history, the FFQ, and the Moos Menstrual Distress Questionnaire (MDQ).

Instruments

Demographic data

Demographic data were collected regarding menstrual history, including the age at menarche, the duration and amount of menstruation, the length and regularity of the menstrual cycle, and the birth control history (oral contraceptives). Other data included age, height/weight, smoking status (yes/no), coffee or caffeine intake (yes/no), and the level of exercise (none: not at all, mild: once/week, moderate: 2–3 times/week, heavy: > 4–5 times/week).

Moos Menstrual Distress Questionnaire

The MDQ was used to assess premenstrual and menstrual symptoms (Moos, 1968; 1985). This instrument has been

widely used in previous PMS studies and demonstrated its reliability when translated into Korean (Cronbach's $\alpha = 0.98$) for use in a study by Kim *et al.* (2000). In Kim *et al.*'s study, 37 items covering six factors from the original MDQ were employed, focusing on pain, water retention, autonomic reactions, negative affect, impaired concentration, and behavioral changes. The participants were asked to recall the severity of 37 symptoms on a 6-point scale, ranging from 0 (not present) to 5 (extreme) throughout the menstrual phases. The reliability of the MDQ was found to be high, as demonstrated by a Cronbach's α of 0.96.

The usual intake of dietary soy isoflavones

The usual intake of dietary soy isoflavones was estimated using the FFQ. It was developed by Lee *et al.* (2000) and consists of 17 items and focuses on the isoflavone content of the soy and soy products frequently consumed by Koreans. This instrument's validity was demonstrated while studying the intake of dietary soy isoflavones among Korean women by Lee (2001). In this study, the consumed foods included rice with soybean, rice with seasoned soy bean sprouts, cooked rice with assorted soybean sprouts, soy paste soup with tofu, soybean paste stew, natto (dambuk) stew, uncurdled tofu stew, pan-fried tofu, steamed tofu, braised, fried soybeans, seasoned soybean sprouts, soup with soybean sprouts, soft tofu stew, miso, seasoned soybean paste, noodles in soybean broth, and soy milk. The participants were asked to recall the frequency and consumption levels of 17 foods on a 9-point scale, including "not at all", "2–3 times/month", "once/month", "once/week", "twice/week", "3–4 times/week", "5–6 times/week", "once a day", and "twice a day", with "small", "moderate", and "large" amounts, respectively.

Lee *et al.* (2000) established an isoflavone content rating for common Korean foods. They developed a formula which was also used in this study: $I = F \times Q \times N$ (where I = isoflavone intake, F = frequency per day, Q = amount per serving, and N = isoflavone content). Lee *et al.* might not have accounted for isoflavone intake as contained in non-soy foods nor for potential recall bias regarding food intake.

RESULTS

Characteristics of sample

Of the 102 women recruited for this study, 84 women (82.4%) provided complete data for analysis. The participating women ranged in age from 28–40 years, with a mean age of 35.49 years (± 4.92). All 84 women were married, 34% reported having two children, and 65% reported no history of oral contraceptive use. The mean age at menarche was 13.3 years ($SD = 1.33$, range = 10–17), the mean menstruation cycle length was 29.6 days ($SD = 2.72$, range = 27–40), and the mean duration of menstruation was 5.03 days ($SD = 1.19$, range = 3–7). Regular menstruation cycles (within 2–3 days of variation) were reported by 36% of the women, and 56.8% rated their menstruation amount as 'moderate'. All the women were non-smokers and 17.6% reported engaging in moderate exercise 2–3 times/week. Furthermore, 79.4% reported drinking coffee and 11.8% reported drinking alcohol. The mean level of soy isoflavone intake for these subjects was 20.29 mg day⁻¹ ($SD = 13.02$, range = 3.12–60.32).

The mean score of the total MDQ results during the premenstrual phase was 34.95 ($SD = 30.55$, range = 0–109), in the menstrual phase it was 35.19 ($SD = 30.77$, range = 0–103), and in the postmenstrual phase it was 9.49 ($SD = 17.47$, range = 0–88). The mean scores of the total MDQ results in the three phases were significantly different ($F = 11.10$, $P = 0.000$). The mean scores of the six subscales, except for "impaired concentration", had statistically significant variations in the three different menstrual phases ($P < 0.005$; Table 1).

Relationships between demographics, level of soy isoflavones intake, and Moos Menstrual Distress Questionnaire scores

Table 2 shows the correlations between demographics, the level of soy isoflavone intake, and total MDQ scores. The isoflavone intake was significantly correlated with the total MDQ scores in the menstrual phase ($r = -0.332$, $P = 0.044$). The correlation between the level of exercise and the total

Table 1. Mean (SD) and mean differences of six subscale and total Moos Menstrual Distress Questionnaire (MDQ) scores in three phases of the menstrual cycle ($n = 84$)

Item	Premenstrual	Menstrual	Postmenstrual	F(p)
Pain	8.57 (7.31)	10.05 (7.04)	2.24 (3.58)	16.49 (0.000*)
Water retention	5.00 (4.28)	3.46 (3.73)	0.95 (2.13)	12.63 (0.000*)
Autonomic reaction	3.76 (4.94)	4.78 (5.24)	1.54 (2.97)	5.03 (0.008*)
Negative affect	8.11 (7.51)	6.38 (6.44)	1.62 (3.80)	11.15 (0.000*)
Impaired concentration	4.86 (7.32)	4.62 (7.03)	1.68 (3.89)	2.96 (0.056)
Behavioral changes	4.65 (4.49)	5.89 (5.86)	1.46 (2.69)	9.40 (0.000*)
MDQ (total)	34.95 (30.55)	35.19 (30.77)	9.49 (17.47)	11.10 (0.000*)

* $P < 0.05$.

Table 2. Pearson correlation coefficients between the variables and the total Moos Menstrual Distress Questionnaire score ($n = 84$)

Variable	Mean (SD) or %	r(p)		
		Premenstrual	Menstrual	Postmenstrual
Age (years)	35.49 (4.92)	-0.042 (0.81)	-0.206 (0.220)	-0.204 (0.23)
Body Mass Index	20.58 (2.08)	-0.226 (0.18)	-0.047 (0.780)	-0.170 (0.31)
Age at menarche (years)	13.27 (1.33)	-0.135 (0.43)	-0.101 (0.550)	-0.013 (0.94)
No. of deliveries	1.67 (1.00)	0.052 (0.76)	-0.206 (0.220)	-0.108 (0.52)
No. of abortions	0.62 (0.92)	-0.034 (0.84)	-0.037 (0.830)	0.122 (0.47)
Length of menses (cycle) (days)	29.62 (2.72)	0.011 (0.95)	-0.222 (0.190)	-0.190 (0.26)
Duration of menstruation (days)	5.03 (1.19)	-0.096 (0.57)	-0.082 (0.630)	-0.108 (0.53)
Grade of menses: moderate (%)	56.80	0.078 (0.65)	-0.086 (0.610)	0.093 (0.58)
Regularity of menses: within 2-3 days (%)	36.00	0.004 (0.98)	0.050 (0.770)	-0.129 (0.45)
Oral contraceptive: no history (%) [†]	65.00	0.226 (0.18)	-0.047 (0.780)	0.044 (0.80)
Coffee drinker (%) [†]	79.40	0.084 (0.62)	-0.032 (0.850)	0.074 (0.67)
Alcohol drinker (%) [†]	11.80	-0.106 (0.53)	0.061 (0.720)	0.189 (0.26)
Exercise level: moderate (%)	21.60	-0.218 (0.20)	-0.458 (0.004*)	-0.255 (0.13)
Soy isoflavone intake (mg/day)	20.29 (13.02)	-0.156 (0.36)	-0.332 (0.044*)	-0.012 (0.94)

* $P < 0.05$. [†] Correlation is based on a dummy variable.

Table 3. Pearson correlation coefficients between the variables and the Moos Menstrual Distress Questionnaire subscales in the menstrual phase ($n = 84$)

Variable	Pain	Water	Autonomic	Negative	Concentration	Behavior
Isoflavone intake	-0.314 (0.060)	-0.048 (0.78)	-0.337 (0.040*)	-0.267 (0.110)	-0.232 (0.167)	-0.464 (0.004*)
Exercise	-0.525 (0.001*)	-0.164 (0.33)	-0.443 (0.006*)	-0.370 (0.024*)	-0.391 (0.017*)	-0.396 (0.015*)

* $P < 0.05$. Autonomic, autonomic reaction; Behavior, behavioral changes; Concentration, impaired concentration; Negative, negative affects; Water, water retention.

MDQ scores in the menstrual phase was moderately significant ($r = -0.458$, $P = 0.004$). Age, Body Mass Index, age at menarche, number of deliveries, number of abortions, length of menstrual cycle, duration of menstruation, grade of menstruation, regularity of menstruation, oral contraceptive use, and coffee & alcohol intake were not significantly correlated with the total MDQ scores.

Table 3 shows the correlations between the level of soy isoflavone intake, exercise, and the MDQ subscale scores in the menstrual phase. The isoflavone intake was significantly correlated with autonomic reactions ($r = -0.337$, $P = 0.04$) and behavioral changes ($r = -0.464$, $P = 0.004$). The exercise level was significantly correlated with all subscale scores except water retention ($r = -0.370 \approx -0.525$, $P < 0.05$).

Additionally, to test the strength of the correlation between exercise and isoflavone intake on the MDQ scores in the menstrual phase, a stepwise regression was performed. Of the variance found in the total MDQ scores in the menstrual phase, 11.4% was accounted for by the level of soy isoflavone intake and 21.0% by the level of exercise.

DISCUSSION

In general, dietary habits and food intake have an influence on both the general and reproductive health of women. The

estimation of the consumption of soy-based foods might be an indicator of a woman's health status and possibly of PMS-related factors. Halbreich (2005) explained that general unspecific improvements in lifestyle, including exercise, improved self-care, and balanced healthy nutrition, are effective for the reduction of PMS symptoms.

Mild, significant, and negative associations between soy isoflavone intake and MDQ scores during the menstrual phase were found in the course of this study. These associations explain 11.4% of the menstrual distress symptom scores. A high intake of soy isoflavones has been shown to decrease the blood estrogen level in premenopausal women (Kruzer, 2002), which might be related to the alleviation of menstrual distress symptoms. Jefferson (2003) found that foods rich in isoflavones or lignans provide a wide range of vital nutrients and form an integral part of the healthy, low-fat, high-fiber diet recommended by dietary experts throughout the world. However, in a study of Japanese women, the soy isoflavone intake was not shown to have any significant relationship with premenstrual and menstrual symptoms (Nagata *et al.*, 2004).

In terms of this study, further research should be focused on the mode of action of soy isoflavones and their responsibility for the positive effects, such as autonomic reactions, behavioral changes, and other effects on menstruation phe-

nomena. Unfortunately, a comparison to prior research findings was not possible because of the lack of research on isoflavone intake among women with PMS. Nonetheless, these results show that soy isoflavone intake might have a beneficial effect on some menstrual cycle-related symptoms.

The level of exercise showed mild to moderate, significant, and negative associations with all subscales of the MDQ scores, except water retention in the menstrual phase, and accounted for 21% of the total MDQ scores in the menstrual phase. Doing exercise probably implies a healthy lifestyle, which is also related positively to the alleviation of menstrual symptoms. This positive correlation supports earlier findings of the positive effect of exercise on mood and general health in regards to PMS (Daugherty, 1998; Ismail & O'Brien, 2000; Dickerson *et al.*, 2003). Exercise also can reduce fluid retention, negative affect, bloating, concentration problems, pain, fear, and guilt (Bosarge, 2003). These effects are also consistent with findings by Aganoff and Boyle (1994), who found that women who exercised regularly improved in all symptoms of PMS on MDQ assessment. However, the impact of exercise on menstrual symptoms might be overestimated because of simplified assessment and clustered results such as none, mild, moderate, and heavy. Therefore, in future research, the frequency, method, duration, and intensity of exercise should be clarified for PMS management and study.

The women in this study consumed an average of 20.29 mg day⁻¹ of soy isoflavones, which is similar to that of middle-aged women in Korea (24.41 mg; Lee *et al.*, 2000). It is higher than that of the national Korean population survey (14.88 mg; Kim & Kwon, 2001) and of women in Hong Kong (19.3 mg; Masdarinec *et al.*, 1998), but lower than that of Japanese women (26.9 mg; Nagata *et al.*, 2004). Japanese women traditionally consume a diet containing large quantities of soy products and consequently have a higher intake of isoflavones than western women. This difference is assumed to be the explanation for the longer menstrual cycle experienced by Japanese women (Jefferson, 2003). In this study, the length of menstrual cycles among Korean women (mean = 29.6, SD = 2.72) was found to be similar to that of Japanese women (mean = 29.4, SD = 3.3; Nagata *et al.*, 2004). Intake levels of soy isoflavones were not significantly related with any other variables except MDQ scores, particularly such as the length of the menstrual cycle. Other researchers had women maintain a diet containing 45 mg day⁻¹ of isoflavones for 1 month, which resulted in an increased menstrual cycle length; however, the study ran for only one menstrual cycle with only six women (Cassidy *et al.*, 1994). In order to appropriately compare the Cassidy findings to those of Nagata, a longer study with a larger sample size would be required.

It is of particular interest that all of the women in this study were non-smokers, which seems to be a reflection of a homogeneously conservative lifestyle among the women. Further explanation is needed as to the relationship between smoking and PMS symptoms.

The level of intake of soy isoflavones in this study was calculated from soy-based foods often consumed by Koreans and its measurement was dependent upon the subject's dietary recall. Kim and Kwon (2001) pointed out the possi-

bility of the underestimation of isoflavone intake as other non-soy food items presumed to contain soy isoflavones, such as meat, eggs, or processed foods (e.g. fried noodles, snacks), were not taken into account. However, as the exact composition of these foods is not readily available, it is difficult to reliably estimate the isoflavone content of such foods containing soy flour and soy protein. Nagata *et al.* (2004) also used a food frequency questionnaire to assess soy isoflavone intake levels and they discussed this measurement error, present in all methods of dietary assessment. Therefore, for a more accurate assessment of isoflavone intake, it would be advantageous to include biological measures, such as urinary isoflavone levels, or other concurrent data, using a food diary. It is necessary to be able to compare the recalled isoflavone intake level (using the FFQ) with a urinary isoflavone level and the actual daily isoflavone intake (using a daily food diary) in order to confirm the validity of the results.

It is also important to note the method of measurement in the MDQ. Yu *et al.* (1996) found the recalled data of PMS symptoms had been overestimated when compared to concurrent reports. Therefore, it is critical to collect PMS symptom reports over the course of at least one menstruation cycle for accurate assessment.

This study is limited by potential measurement errors in dietary recall, PMS symptoms recall, and of isoflavone intake levels related to unreported food intake on the FFQ. If such errors occurred, they would contribute to positive or negative effects in the findings in many aspects.

In conclusion, the beneficial effect of dietary soy isoflavones on some menstrual symptoms among Korean women living in the USA was examined. The findings suggest that soy isoflavones can be added as one of the relating factors to PMS phenomena and can further expand our understanding of the complexity surrounding PMS. In the practise of PMS assessment and management, it is necessary that diet appraisals include a measurement of soy isoflavones intake, and any relationship between dietary/nutritional imbalances and PMS symptomatology should be identified. This measurement will lead to an evidence-based recommendation of a soy isoflavones diet as an integral part of PMS management. Further study on isoflavones and women's health concerns will elucidate their relationship and ultimately will contribute to the general promotion of health in women. In further work, a replication study with a large sample of women living in Korea is necessary, as well as more research into food intake and its effects on PMS.

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