Caffeine-Containing Beverages, Total Fluid Consumption, and Premenstrual Syndrome

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Abstract: The main objective of this study was to evaluate whether daily consumption of caffeine-containing beverages is related to the prevalence and severity of premenstrual syndrome apart from any effects of daily total fluid consumption. A secondary objective was to determine whether daily total fluid consumption itself is related to premenstrual syndrome. The study is based on 841 responses to a questionnaire probing menstrual and premenstrual health, and daily fluid consumption, which was mailed to female university students in Oregon. Analysis of the data revealed that consumption of caffeine-containing beverages was strongly related to the prevalence of premenstrual syndrome. Among women with more severe symptoms, the relation between consumption of caffeine-containing beverages and premenstrual syndrome was dose-dependent, with prevalence odds ratios equal to 1.3 for consumers of one cup of a caffeine-containing beverage per day and increasing steadily to 7.0 for consumers of eight to 10 cups per day. The effects were apparent among both caffeine-containing tea/coffee consumers and caffeine-containing soda consumers. The observed effects were only slightly reduced when daily total fluid consumption was controlled. Daily total fluid consumption also was related to the prevalence of premenstrual symptoms although the effects were large only for consumers of 13–19 cups of fluid per day (the largest amount studied). (*Am J Public Health* 1990; 80:1106–1110.)

Introduction

Previous investigations have indicated that the consumption of caffeine-containing beverages is strongly related to the prevalence and severity of premenstrual syndrome (PMS), and that such effects exist for a wide variety of premenstrual symptoms.[1-4] Further work demonstrated that the association between premenstrual symptoms and consumption of caffeine-containing beverages occurs even among women who lack other putative causes of the syndrome.[5] Such putative causes included alcohol use, cigarette use, lack of exercise, oral contraceptive use, and a diet high in beef and refined sugar products.[6-18]

One possible explanation for the observed association between consumption of caffeine-containing beverages and premenstrual symptoms is that consumption of these beverages is related to daily total fluid consumption, and that it is daily total fluid consumption which is causally related to premenstrual symptoms. Such an explanation might be consistent with the retention of fluid experienced by many women who report premenstrual symptoms.

This study was undertaken to assess the relation between premenstrual syndrome and caffeine-containing beverage intake, and between premenstrual syndrome and total fluid intake, controlling for any confounding effects attributable to the other variable. In addition, we wanted to describe the dose-response relation between premenstrual syndrome and consumption of caffeine-containing beverages and of total fluid, and to discover which types of caffeine-containing beverages might exert an effect.

Methods

Study Population and Data Collection

The study was conducted at a public university in Oregon. Eligible subjects were the 1,419 currently enrolled, female students who resided in any of the university's residential dormitories.

In October 1988, each eligible student was sent a questionnaire, together with a cover letter explaining the general nature of the study (a study of women's health) and requesting her participation. The questionnaire solicited information about the presence and severity of premenstrual symptoms and of menstrual symptoms, demographic characteristics, use of over-the-counter drugs containing caffeine, and typical daily consumption of beverages including caffeine-containing beverages. The questions pertaining to premenstrual symptoms asked each respondent to indicate whether she experienced premenstrual symptoms and, if she did, to score the severity (mild, moderate, or severe) of each in a list of 10 premenstrual symptoms plus an "other symptom" category. To reduce the likelihood that the study participants would suspect the hypotheses under investigation, we included questions about menstrual health similar in number and detail to those probing premenstrual health. A definition of the syndrome, which emphasized the timing of symptoms with respect to the onset of menses, was included in the questionnaire.

The questions pertaining to daily beverage intake asked for the number of cups, defined on the questionnaire as "eight ounces, or one measuring cupful," of each in a list of 11 beverages plus an "other beverage" category the respondent consumed during a typical day. One of the 11 beverages was water.

Eight-hundred-and-sixty-nine women (61 percent) returned the questionnaire after two mailings. (The second mailing was conducted in January 1989.) The data for 28 women subsequently were excluded from the data analysis: two women reported having endometriosis, four women did not menstruate on a regular basis, and 10 women did not provide information on the presence of premenstrual symptoms or on the daily consumption of beverages. An additional 12 respondents were excluded because their daily consumption of caffeine-containing beverages was between 11 and 30 cups, making the cup-specific prevalence odds estimates unstable (as described in the section on data analysis). These exclusions left data on 841 women for analysis. Ninety-six percent of these women were between the ages of 18 and 22 years.

Data Analysis

We estimated the premenstrual syndrome prevalence odds ratios, the odds of having premenstrual syndrome among "exposed" women divided by the odds among "unexposed" women, for five levels of daily consumption of caffeine-containing beverages (one cup, two to four cups, five cups, six or seven cups, and eight to 10 cups) and for four levels of daily total fluid intake (six or seven cups, eight to 10 cups, 11 to 12 cups, and 13 to 19 cups). These intervals were determined empirically on the basis of the uniformity of the premenstrual syndrome prevalence odds ratio point estimates for each level of consumption within an interval. For the three subjects who used caffeine-containing drugs on a daily basis, the estimates of the number of cups of a caffeine-containing beverage consumed each day were increased. The amount of increase equaled the equivalent number of cups of a caffeine-containing beverage for the caffeine content of the drug. The equivalency was determined by the information provided on each drug's packaging material. There were too few subjects who reported consuming more than 10 cups of a caffeine-containing beverage each day, or more than 19 cups of total fluid each day, to provide information for higher levels of consumption. Daily total fluid consumption was calculated by summing the numbers of cups of beverages consumed each day for each of the 11 listed beverages plus the "other" beverage category.

Confidence intervals for the prevalence odds ratios were based on Miettinen's test-based procedure, using the programs of Rothman and Boice.[19]

The overall trend in the data relating premenstrual symptoms and caffeine-containing beverages intake, and premenstrual symptoms and total fluid intake, was tested using the method described by Mantel.[20] The method of maximum likelihood was used to estimate the slope, and standard error for the slope, for the logistic curve relating premenstrual syndrome and daily consumption of caffeine-containing beverages or daily total fluid intake.[21]

We assessed the magnitude of confounding of the premenstrual syndrome prevalence odds ratio by either daily consumption of caffeine-containing beverages or by daily total fluid consumption (depending upon which of these two variables was the variable of interest) by stratifying the data into categories of the potential confounding factor and obtaining an estimate for a uniform prevalence odds ratio by the method of maximum likelihood.[22] The categories used were identical to the categories formed by empirically determining the intervals over which the premenstrual syndrome prevalence odds ratio was uniform.

The level of severity of premenstrual syndrome was determined by each participant in response to a question asking her to assess the overall severity of her symptoms. In addition, a "PMS score" was calculated for each woman. This score was equal to the sum of each respondent's rating of severity for each in the list of 10 symptoms plus the "other" symptoms category, as contained in the questionnaire. A score of one was assigned to each symptom rated mild, a score of two was assigned to each moderate symptom, and a score of three was assigned to each severe symptom. The range of possible PMS scores, therefore, was 0 (no premenstrual symptoms) to 33 (11 severe symptoms).

Results

Prevalence of Premenstrual Symptoms and Types of Beverages Consumed

Six-hundred-and-sixteen (73 percent) of the 841 respondents reported experiencing at least one premenstrual symp-tom, and 603 (72 percent) reported consuming at least one cup of a caffeine-containing beverage each day. For all types of beverages consumed, a total of 7,048 cups of fluid were reported to be consumed each day: 39 percent water, 20 percent caffeine-containing soda, 12 percent fruit juice, 11 percent milk, 6 percent caffeine-containing coffee, 6 percent caffeine-free soda, 3 percent hot chocolate, 2 percent each caffeine-containing tea and herbal tea, and less than 1 percent each decaffeinated coffee and grain beverages: other beverages accounted for less than 1 percent of the total cups consumed. Seventy-one percent of the total volume of caffeine-containing beverage consumed was soda, 21 percent was coffee, and 8 percent was tea.

Consumption of Caffeine-containing Beverages

The overall prevalence odds ratio for daily consumption of one to 10 caffeine-containing beverages among women who reported experiencing at least one premenstrual symptom compared with women who reported no premenstrual symptoms was 1.5 (90% confidence interval = 1.1, 2.0). This effect was restricted primarily to women whose PMS scores equaled 16 through 31 (the highest score observed).

For the 399 women with PMS scores between 1 and 15 (median score = 9), the prevalence odds ratio for daily consumption of any caffeine-containing beverages (one to ten cups per day) was 1.3 (90% CI = 0.9, 1.7). This point estimate remained unchanged when controlled for daily total fluid consumption. The estimates for one to five cups per day, and for six to 10 cups per day, were similar (1.2 and 1.1, respectively) when daily total fluid consumption was controlled (Table 1).

Among women with PMS scores from 1 to 15, 61 percent rated the overall severity of their PMS symptoms "mild" while only 2 percent rated their symptoms "severe."

Table 2 shows the prevalence odds ratios of premenstrual syndrome for consumption of caffeine-containing beverages among the 217 women whose PMS scores equaled 16 through 31 (median score = 19). For these women, the overall prevalence odds ratio (one to 10 cups of caffeine-containing beverages per day relative to no cups) was 2.0 (90% CI = 1.4, 2.9). A steadily increasing prevalence odds ratio was observed for increasing amounts of daily consumption of caffeine-containing beverages, ranging from 1.3 for one cup per day to 7.0 for eight to 10 cups per day. All of the estimated prevalence odds ratios, except the estimate for one cup per day, were slightly reduced when daily total fluid consumption was controlled (Table 2).

The p-value of the test for trend between premenstrual syndrome and daily cups of caffeine-containing beverages

TABLE 1—Prevalence Odds Ratios of Premenstrual Syndrome According to Daily Consumption of Caffeine-containing Beverage Consumption among the 399 Women Whose PMS Scores Equaled 1 through 15

Control for Total Fluid	Daily Consumption of Caffeine-containing Beverages (Cups)		
	0 POR*	1–5 POR*	6–10 POR*
No	1.0	1.2 (0.9, 1.7)	1.6 (0.8, 3.1)
Yes	1.0	1.2 (0.9, 1.7)	1.1 (0.6, 2.4)
Number of Exposed Women**	194	396	34

*Prevalence Odds Ratio, Relative to 0 Cups per Day (90% Confidence Interval).
**Includes Cases and Controls.

TABLE 2—Prevalence Odds Ratios of Premenstrual Syndrome According to Daily Consumption of Caffeine-containing Beverages with and without Controlling for Daily Consumption of Total Fluid Intake among the 217 Women Whose PMS Scores Equaled 16 through 31

Control for Total Fluid	Daily Consumption of Caffeine-containing Beverages (Cups)					
	0 POR*	1 POR*	2–4 POR*	5 POR*	6–7 POR*	8–10 POR*
No	1.0	1.3	2.0	2.5	5.0	7.0
Yes	1.0	1.3	1.8	2.1	3.3	6.5
Number of Exposed Women**	121	85	172	22	27	15

*Prevalence Odds Ratio, Relative to 0 Cups per Day.
**Includes Cases and Controls.

consumed was <0.001. The slope of the logistic curve relating premenstrual syndrome and daily consumption of caffeine-containing beverages (without control for total fluid intake) was 0.22 (standard error = 0.047). The slope of the logistic curve relating premenstrual syndrome and caffeine-containing beverage consumption, controlling for daily total fluid intake, was reduced to 0.18 (standard error = 0.046); thus, each additional daily cup of caffeine-containing beverage was associated with a 20 percent increase in the prevalence of premenstrual syndrome (e · 18 = 1.2).

Among women with PMS scores from 16 to 31, 12 percent rated the overall severity of her symptoms "mild" while 18 percent rated her symptoms "severe."

Types of Caffeine-containing Beverages

Table 3 shows the prevalence odds ratios of premenstrual syndrome among women with PMS scores equal to 16 through 31 who consumed either caffeine-containing soda or caffeine-containing tea or coffee on a daily basis. The data show that both caffeine-containing soda and caffeine-containing tea/coffee were associated with an increase in the prevalence of premenstrual symptoms, and that the effect was higher, per amount of exposure, for consumers of tea/coffee than for soda consumers over the range of consumption studied (0 to 8 cups of soda, and 0 to 3 cups of

TABLE 3—Prevalence Odds Ratios of Premenstrual Syndrome According to Daily Consumption of Caffeine-containing Soda or Tea/Coffee among Women Whose PMS Scores Equaled 16 through 31

Daily Consumption of Caffeine-containing Soda (Cups)**		
0 POR*	1–5 POR*	6–8 POR*
1.0	1.3 (0.9, 2.0)	7.0 (2.1, 22.9)

Daily Consumption of Caffeine-containing Tea/Coffee (Cups)***		
0 POR*	1 POR*	2–3 POR*
1.0	1.4 (0.6, 3.3)	5.3 (2.3, 12.2)

*Prevalence Odds Ratio, Relative to 0 Cups per Day (90% Confidence Interval).
**Based on the 176 cases who consumed caffeine-containing soda on a daily basis but who did not consume caffeine-containing tea or coffee, and on 121 cases who consumed no caffeine-containing beverages.
***Based on the 41 cases who consumed caffeine-containing tea or coffee on a daily basis but who did not consume caffeine-containing soda, and on 121 cases who consumed no caffeine-containing beverages.

tea/coffee). There were too few data on which to base effect estimates for larger amounts of consumption.

Total Fluid Intake

The overall prevalence odds ratio for daily consumption of six to 19 cups of fluid, relative to daily consumption of two to five cups, among women who reported experiencing at least one premenstrual symptom compared with women who reported no symptoms was 1.7 (90% CI = 1.0, 3.0). The prevalence odds ratios for women with PMS scores between 1 and 15 (less severe symptoms) were 1.2 (0.6, 2.4), 1.7 (0.9, 3.3), and 2.1 (1.0, 4.5) for 6–7 cups per day, 8 to 10 cups per day, and 11–19 cups per day, respectively.

Table 4 shows the prevalence odds ratios of premenstrual syndrome for total fluid intake, with and without control for daily consumption of caffeine-containing beverages among the 217 women with PMS scores between 16 and 31 (the same subset of women referred to in Table 2). For these women, the overall prevalence odds ratio (six to 19 cups of fluid consumed per day relative to two to five cups consumed per day) was 1.7 (90% CI = 1.1, 2.7). A steadily increasing prevalence odds ratio was observed for increasing amounts of daily total fluid intake, although the size of the increase was small from six or seven to 11–12 cups of fluid per day. The prevalence odds ratio estimates were reduced somewhat when daily consumption of caffeine-containing beverages was controlled. In both sets of estimates, the only large effects observed were among women consuming between 13 and 19 cups of fluid each day.

The p-values associated with the overall trend between premenstrual syndrome and daily total fluid intake were <0.001 and 0.01 without and with control for daily consumption of caffeine-containing beverages, respectively. The corresponding slopes of the logistic curves were 0.091 (standard error = 0.027) and 0.065 (standard error = 0.026).

Discussion

We found a strong association between consumption of caffeine-containing beverages and the prevalence of premenstrual symptoms which was not explained by daily total fluid consumption. The effects for women with PMS scores between 16 and 31 (women with more severe symptoms) were highly dose-dependent, and were present both among women whose source of caffeine was soda and to a stronger extent (on a per cup basis) among women whose source of caffeine was tea and/or coffee. The relation between daily total fluid consumption and premenstrual symptoms, both with and without control for daily consumption of caffeine-

TABLE 4—Prevalence Odds Ratios of Premenstrual Syndrome According to Daily Total Fluid Consumption with and without Controlling for Daily Consumption of Caffeine-containing Beverages among the 217 Women Whose PMS Scores Equaled 16 through 31

Control for Caffeine-containing Beverages	Daily Total Fluid Consumption (Cups)				
	2–5 POR*	6–7 POR*	8–10 POR*	11–12 POR*	13–19 POR*
No	1.0	1.3	1.5	1.7	3.4
Yes	1.0	1.2	1.3	1.5	2.3
Number of Exposed Women**	59	102	144	63	66

*Prevalence Odds Ratio, Relative to 2–5 Cups per Day.
**Includes Cases and Controls.

containing beverages, was more moderate (over the ranges of values studied) than was the relation for daily consumption of caffeine-containing beverages. The relation between premenstrual symptoms and daily total fluid intake appeared to be dose-dependent, at least when the highest level of intake (13–19 cups per day) was taken into account. The fact that the estimated effects for daily total fluid intake were similar for women with PMS scores between one and 15 (mild symptoms), and for women with PMS scores between 16 and 31 (more severe symptoms), however, seems difficult to reconcile with a causal interpretation of the observed effects.

One possible source of error in this study warrants discussion. We used a self-administered questionnaire to collect information about the presence and severity of premenstrual symptoms. Although a definition of premenstrual syndrome was included in the questionnaire, it may be that some women confused premenstrual with menstrual symptoms or otherwise misinterpreted the meaning of "premenstrual symptoms," and responded accordingly. To evaluate this possibility, 51 study participants volunteered to keep a three-month daily record of symptoms, and to record the first and last days of their menstrual periods. (These women also maintained a daily record of certain dietary factors, exercise history, and stressful life events which may have affected daily symptoms such as anxiety or depression.) These women were told that the purpose of the daily diary was to obtain more detailed information about symptoms throughout the menstrual cycle than was possible using a one-time mail questionnaire. Forty-three (84 percent) of the volunteers completed at least two months of the daily diary. Of these women, 32 (74 percent) completed all three months. One of us (AMR), blinded with respect to the volunteers' responses on the mail questionnaire, rated the severity of premenstrual symptoms (no symptoms, mild, or moderate/severe) for each of the 43 subjects who completed at least two months of the diary, and then compared these ratings to the PMS scores as determined from each woman's mail questionnaire. Overall, 60 percent (26/43) of the ratings and PMS scores matched; that is, the blind assessment of severity, which was based on the actual symptoms recorded in the daily diaries, corresponded to the assessment of PMS severity as summarized in the PMS score (0 = no PMS, 1–15 = mild, 16 or higher = moderate/severe). The majority of the misclassification (11 of 17 misclassified cases) occurred among women who were rated as not having premenstrual syndrome but whose PMS scores equaled one to 15 (mild). Considerably less misclassification occurred between other categories of PMS severity.

The effects of such misclassification, if generalizable to the other study participants, would be to reduce somewhat the size of the observed associations between consumption of caffeine-containing beverages or total fluid intake and PMS among women with PMS scores of 16 or higher, and to substantially reduce the size of the observed associations between consumption of caffeine-containing beverages or total fluid intake and PMS among women with scores of one to 15. The lack of a strong, observed association between consumption of caffeine-containing beverages and PMS among women with PMS scores of one to 15 may be attributable in large part to the inclusion of women who do not regularly experience premenstrual symptoms into this PMS group.

Neither observation bias nor selection bias would seem to be a potentially large source of error in the present study because data from both women who experience premenstrual symptoms and women who do not experience these symptoms were collected in the same manner using identical mail questionnaires; the questionnaire contained an equal number of questions about menstrual health as it contained about premenstrual health; the study hypothesis was not disclosed to the study participants nor is the hypothesis generally well-known or accepted to be true among the population studied; and none of the 51 study participants who volunteered to keep daily records of symptoms (with whom there was bi-weekly personal contact) indicated that she suspected the specific nature of the study hypotheses.

The observed associations between premenstrual symptoms and daily consumption of caffeine-containing beverages theoretically could reflect some uncontrolled third factor but any such factor would have to be present among both caffeine-containing soda consumers and among caffeine-containing tea/coffee consumers, would have to vary jointly with the amounts of such beverages consumed, and would have to be prevalent among young women in both the United States and the People's Republic of China.[5] Neither alcohol use, cigarette use, exercise habits, oral contraceptive use, nor a diet high in beef or refined sugar products, all putative causes/preventives of premenstrual syndrome, satisfies such criteria. A mechanism involving the depressive action of adenosine on central neurons has been suggested by Phillis for how caffeine might cause premenstrual syndrome.[23]

Theoretically, a definitive evaluation of the effects, if any, of caffeine-containing beverages on premenstrual syndrome would involve a randomized trial. The inherent difficulties in conducting such a trial, however, would be considerable.

It seems worth considering that the etiological factors of premenstrual syndrome may operate anew during each menstrual cycle, making the latent period between exposure to caffeine-containing beverages and the onset of premenstrual syndrome short. If true, any beneficial effects which arise from the elimination of caffeine from the diet should be apparent within a relatively few menstrual cycles. For this reason, and because there are few, if any, known beneficial effects associated with caffeine-containing beverage consumption, women who wish to reduce the severity of their premenstrual symptoms may want to consider eliminating caffeine-containing beverages from their diets and then evaluating any changes in the severity of their symptoms after several months. Such a decision, determined on the basis of each woman's personal history with premenstrual symptoms, should be made with full knowledge that there may be no benefits derived from such abstinence for a particular woman. This is the case, however, for many public health recommendations whose bases reside in population-based (epidemiologic) research.

APPENDIX

Subset of the Questionnaire: Question About Beverage Intake

23. About how many *cups* of each of the following beverages do you drink during a typical *day?* (One "cup" is equal to about eight ounces, or one measuring cupful.)

Water:_____
Fruit juice_____
Milk_____
Caffeine-free soft drink_____
Caffeine-containing soft drink_____
Hot chocolate_____
Decaffeinated coffee_____
Caffeine-containing coffee_____
Herbal tea (non-caffeine-containing tea)_____
Caffeine-containing tea_____
Milk shake, ice cream soda_____
Other beverages (note that alcoholic drinks are listed in question 24)_____

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CPHA to Sponsor November 29 Symposium on Proposals for ICD–10

With the implementation of the 10th revision of the *International Classification of Diseases* (ICD–10) scheduled for the first half of this decade, health care providers, policy makers, and others will be able to classify and collect more comprehensive patient data than ever before. ICD–10 represents a complete restructuring of ICD–9–CM, the classification system currently used in the United States to code patient diagnoses in the inpatient hospital setting. Designers of ICD–10 are structuring the new taxonomy so that health care professionals will be able to capture data that will facilitate "cradle to grave" health care analyses.

To address the changes in coding technology that will result with ICD–10, the Commission on Professional and Hospital Activities (CPHA) of Ann Arbor, Michigan is sponsoring a national symposium in Chicago, November 29, 1990. Attendees at the symposium will evaluate the work that has been done thus far on chapter 21 of ICD–10, which deals in large part with ancillary factors, such as social environment or occupational hazards which influence the patient's health status and necessitate contact with health services, both as an inpatient and in the ambulatory setting. Participants from national organizations, speakers who will address specific issues, and a reactor panel all will be featured in the symposium. Health care professionals interested in learning more about the conference or in participating on the reactor panel should contact Marge Zernott, Director of Classification Development at CPHA, tel: (313) 930-7990.