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Prevalence of Premenstrual Syndrome and Changes in Blood Pressure with Menstrual Cycle Among University Students

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Summary: We aimed to investigate prospectively the prevalence of premenstrual symptoms (PSM), changes in blood pressure with menstrual cycles and to investigate the relative severity of each symptoms and to cluster these symptoms into factors, and the relative contributions of each factor in a sample of undergraduate students of Ahmadu Bello University, Zaria and Bingham University, Karu. A total of 370 female undergraduate students reported on the severity of 23 PMS in a full cycle. Their blood pressures (BP) were measured during follicular and luteal phases. Paired sample student *t*-test was used to investigate difference in mean of blood pressures based on menstrual phases. We fitted PCA to cluster the symptoms. Backache, wish to be alone, joint or muscle pain, fatigue, and pain in the thigh were the five most frequently reported symptoms. About 89% of the participants reported experiencing at least one symptom during each cycle. Mean arterial blood pressure, systolic, and diastolic blood pressures were significantly (P <0.001) higher at the luteal phase than at the follicular phase while, pulse rate was significantly higher (P <0.001) at the follicular phase than the luteal phase. The 23 symptoms were reduced into four clusters; affective, physical, somatic, and GIT/physical symptoms. In conclusion, our findings indicate a high prevalence of PMS with majority indicating that the symptoms as mild to severe. Blood pressure significantly increased at luteal phase than follicular phase. The 23 symptoms were reduced into four clusters.

Keywords*:* Premenstrual syndrome, Blood pressure, Menstruation

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INTRODUCTION

Premenstrual symptoms, commonly referred to as premenstrual syndrome (PMS) is a group of physical, psychological, and behavioural symptoms experienced by premenopausal women during the luteal phase of their menstrual cycle (Usman *et al.*, 2008). Diagnostic criteria for PMS was published by the American College of Obstetrics and Gynaecology (ACOG, 2000), and states as follows: a woman is considered to have PMS if she reports having at least one of the 6 affective symptoms and one of the 4 somatic symptoms 5 days prior to onset of menstruation in 3 previous consecutive cycles and the symptoms should remit within 4 days of menses onset and that the symptoms should not recur until at least day 13 of the next cycle. The cause of PMS is unclear. However, it is believed that serotonin, progesterone, regulation of gonadotrophins secretion by endorphin, psychological and biosocial factors play a key role in its aetiology (Yonkers *et al.*, 2008).

Commonly reported symptoms include headaches, breast tenderness, depression, anxiety, social withdrawal, food cravings, abdominal bloating, fatigue, mood swings, irritability, and oedema. Although affected women don't suffer all these symptoms at the same time, most women however, report suffering from recurrent symptoms of PMS during each cycle (Grosz, 1988). Symptoms of PMS are evident 4-7 days (premenstrual phase) prior to and in some cases, during menstruation (Braverman, 2007). Studies from developed and developing countries have consistently reported the existence of these symptoms and dysmenorrhoea among women of childbearing age and nationalities (Hallow and Campbell, 2004; French, 2005; Tabassum *et al.*, 2005; Latthe *et al.*, 2006; Pinar *et al.*, 2011).

There has not been agreement in the prevalence estimates of PMS among authors (Sammon *et al.*, 2016). It has been shown that about 50-90% of premenopausal women report at least symptom of PMS, 10-30% report symptoms of PMS that interfere

with daily activities, while about 1-8% report at least five psychological symptoms that meet premenstrual dysphoric disorder (PMDD) criteria (Halbreich *et al.*, 2003). A study by Hylan *et al.* (1999) in the UK reported 31% as having severe symptoms of PMS out of which 53% sought medical intervention. Similar studies in the USA and France in 1998, reported 45% and 29% respectively, of women reporting severe symptoms of PMS seeking for medical intervention, while in Switzerland, 41% of women with severe symptoms of PMS reported seeking medical help in a study conducted between 1986 and 1993 (Angst *et al.*, 2001).

Variabilities in blood pressure during menstrual cycle among Nigerian females are not well documented, and available studies have conflicting reports. Earlier study by Greenberg and colleagues (1985) reported a higher systolic blood pressure (SBP) at days 17 – 26 (luteal phase) of the cycle than at other phases of the cycle. Contrary to this cross-sectional study, in a smaller prospective study, this same group found significant decrease in diastolic blood pressure (DBP) at days 17 – 26 than in other phases of the cycle in a sample of 33 women who were visited three times on weekly basis for 8 consecutive weeks. Kelleher and colleagues (1986) performed similar prospective study on 18 women and reported a significant increase in SBP at the premenstrual phase. Consequently, increase in SBP at ovulatory phase has also been reported (Freedman *et al.*, 1974). Hassan *et al.* (1990) found that SBP was similar at the menstrual phase, days 1 – 2; at the late follicular phase, days 12 – 15 and at the late luteal phase, days 21 – 26, while DBP was significantly lower at the luteal phase. However, Dunne *et al.* (1991) reported a significantly higher SBP and DBP at onset of bleeding than at most other phases of the cycle. However, after adjustment, DBP was found to be higher in the follicular than at the luteal phase. Various mechanisms have been suggested to interplay between PMS and increase in blood pressure. Notable is the renin-angiotensin-aldosterone system dysfunction and deficiencies of micronutrients (Bertone-Johnson *et al.*, 2005; Rosenfeld *et al.*, 2008; Chocano-Bedoya *et al.*, 2011; 2013).

To better understand the prevalence of PMS and the changes in blood pressure during follicular and luteal phases of menstrual cycle, we report the findings from 370 undergraduate students. We first sought the prevalence of PMS among the students then investigate the extent to which participants report severity of premenstrual symptoms. We then aimed to explore the changes in arterial and blood pressures during follicular and luteal phases. Finally, we investigated phenotypic factor loadings of PMS.

MATERIALS AND METHODS

The prospective study was conducted in Ahmadu Bello University, Zaria, and Bingham University, Karu, in Northwestern and Northcentral Nigeria respectively. Data were obtained from subjects using structured questionnaires that were randomly administered to them. The sample included 370 undergraduate female students, aged 16-33 years. All subjects have regular menstrual cycles of between 28 – 34 days. No subject reported taking medication known to alter blood pressure and none was on oral contraceptives in the past 6 months prior to the study. Oral contraceptives have been reported to both exacerbate and alleviate PMS (Severino and Moline, 1989). The study was approved by Ahmadu Bello University Research and Ethics Committee. Participants provided informed consent prior to the study. Subjects were also informed that participation was voluntary and that they can withdraw at any time. Data were collected at inception of semester.

Questionnaire

The study was based on a questionnaire distributed to the students in their hostels. Brief description of the study was made to each subject, followed by issuance of consent form and questionnaire. The questionnaire consisted of three sections. A general section concerned with self-reported data of subject and those of her family such as age, menarcheal age, size of sibship, ethnic affiliation, place of residency (urban or rural), parents' level of education. Parental education was categorized into four groups: no formal education, primary, secondary, and tertiary education. Anthropometric and physiological section in which weight, height, SBP and DBP measurements were taken. Finally, symptoms of PMS section which included 23 symptoms of PMS were reported prospectively in one cycle. This section asked the subjects to tick each item according to the degree of severity, graded with a Likert-type scale from 1 to 4 (no pain, mild pain, moderate pain, severe pain) to all 23 symptoms. Hostel number and phone number of each participant was collected in order to track them. Subjects were asked to tick the severity of each of the 23 symptoms of PMS on the questionnaire.

Measurements and Protocol

Anthropometry. Weight and height were measured twice, and the average was calculated. Weight was measured to 0.1 kg using a standard beam balance in minimal clothing and bare feet. Height was determined to the nearest 1 mm with portable stadiometers. The portable scale and stadiometer were calibrated each day. BMI was calculated according to the formula:

$$\text{BMI (kg/m}^2\text{)} = \frac{weight\ (kg)}{height\ (m^2)}$$

All measurements of heights and weights were taken by two of the authors; J.K. and C.E. according to

standardized anthropometric techniques (Lohman *et al.*, 1988).

Blood pressure

Blood pressure of subjects was measured in a systematized approach at different stages of their menstrual cycles as follows: days 1 – 6, days 7 – 14, days 15 – 23 and days 24 – 28, with adjustment for cycles lengths 29 and 34 days (no subject reported having cycle length <28 days). Follicular phase was dated as days 1 – 14 while luteal phase was dated as days 15 – 28. Two consecutive blood pressures were measured each morning of the study per stage and the average calculated as the blood pressure for that stage. The average of blood pressure for days 1 – 6 and 7 – 14 constitutes the follicular phase while the average of blood pressure for days 15 – 23 and 24 – 28 constitutes the luteal phase. To account for variabilities in temperature, all blood pressure measurements were taken in the hostel. The phase of the cycle at point of entry was determined from the date of onset of bleeding.

The indirect (auscultatory) method was employed to measure the SBP and DBP with the use of sphygmomanometer. Briefly, an inflatable cuff containing a pressure gauge was wrapped around the upper arm, and a stethoscope was placed over the brachial artery just below the cuff. The cuff occludes the brachial artery due to compression. The cuff was then inflated with air to a pressure greater than SBP. Systolic blood pressure was recorded following an appearance of tapping sound while DBP was recorded following disappearance of muffling sound. Pulse rate was recorded as the number of pulse per minute at the radial artery with the middle finger. Mean arterial pressure was calculated using the formula:

Mean arterial pressure =

$$\text{diastolic pressure} + \frac{1}{3}(\text{systolic pressure} - \text{diastolic pressure})$$

Statistical Analysis

Descriptive statistics including means and standard deviations were calculated for sociodemographic, anthropological, and physiological variables. Paired sample *t*-test was used to calculate difference in means of physiological variables based on menstrual cycle. Statistical analyses were performed using STATISTICA™ version 7 (StatSoft, Tulsa, OK). *P* values <0.05 (two-tailed) were considered statistically significant.

RESULTS

In total, 370 female students, aged 16-33 (mean age20.66 ± 2.29), were included in the study. The participants' baseline characteristics are presented in Table 1. The participants were undergraduate students of Ahmadu Bello University Zaria and Bingham University Karu. Mean age at menarche was 12.74 ± 1.98 years. Means and standard deviations of their weight, height, and BMI are also presented on the same table. The prevalence of PMS was 89%, that is, 329 subjects reported having at least one symptom of PMS while 11% (41 subjects) did not report any symptom of PMS (Figure 1). Figure 2 presents severity of PMS as reported by the 329 subjects who reported

Table 1: Participant characteristics at baseline (n = 370)

	Mean ± SD	Range
Age (yrs.)	20.66 ± 2.29	16.00 – 33.00
Menarcheal age yrs.)	12.74 ± 1.98	8.00 – 15.00
Weight (kg)	58.78 ± 11.65	39.00 – 120.00
Height (cm)	160.85 ± 7.27	145.00 – 188.00
BMI (kgm^{-2})	22.68 ± 3.91	15.62 – 44.62

BMI = body mass index

Table 2: Comparison of physiological variables during follicular and menstrual cycle

	Follicular phase	Luteal phase
Physiologic variables	Mean ± SD	Mean ± SD
Systolic blood pressure (mm Hg)	111 ± 13	117 ± 10*
Diastolic blood pressure (mm Hg)	73 ± 13	79 ± 9*
Pulse rate (beats/min)	81 ± 13	76 ± 11*
Mean arterial pressure (mm Hg)	100 ± 13	104 ± 10*

*: P<0.001

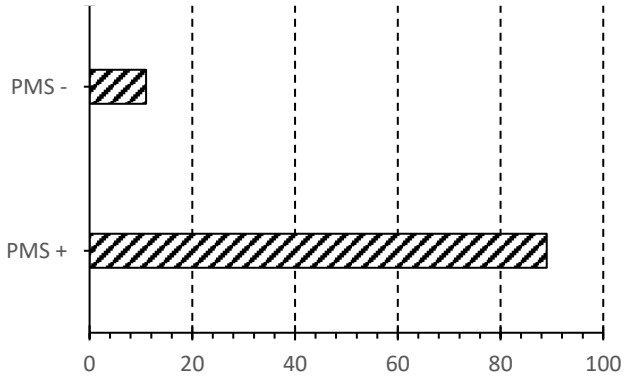

Figure 1. Prevalence of PMS

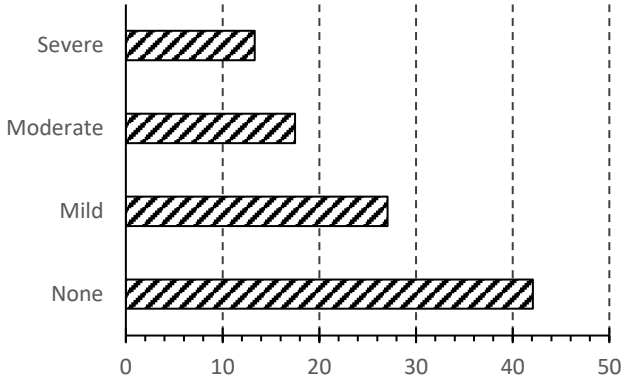

Figure 2. Degree of severity of PMS among the subjects

Table 3: Premenstrual symptom loads experienced by participants in one menstrual cycle

	Degree of severity				
Premenstrual symptoms	**No (%)**	**Mild (%)**	**Moderate (%)**	**Severe (%)**	**Mean ± SD**
Backache	25	21	18	36	1.65 ± 1.21
Wish to be alone	31	20	21	28	1.47 ± 1.20
Joint or muscle pain	34	20	21	25	1.38 ± 1.20
Fatigue	26	26	24	24	1.37 ± 1.02
Pain in the thigh	35	18	25	22	1.35 ± 1.17
Acne/pimples	31	31	18	20	1.19 ± 1.03
Reduced urination	51	13	20	16	1.19 ± 1.03
Depression	35	28	21	16	1.17 ± 1.08
Loss of appetite	37	23	25	15	1.17 ± 1.09
Difficult concentration	40	23	22	15	1.13 ± 1.11
Aggressiveness	43	19	24	14	1.10 ± 1.11
Sleeplessness	44	22	18	16	1.06 ± 1.12
Oily skin	41	26	20	13	1.03 ± 1.06
Dizziness	45	25	17	13	0.97 ± 1.06
Excessive sleep	50	22	15	13	0.90 ± 1.07
Nausea/vomiting	55	16	16	13	0.86 ± 1.10
Crying spells	57	20	13	10	0.78 ± 1.04
Diarrhoea	57	19	16	8	0.76 ± 1.01
Headache	56	20	17	7	0.73 ± 0.96
Overeating	60	18	12	10	0.71 ± 1.01
Sweating	58	21	13	8	0.70 ± 0.97
Confusion	61	16	16	7	0.69 ± 0.98
Constipation	70	12	12	6	0.53 ± 0.91

Table 4: Factor loadings for PMS symptoms from four factor analyses

	Factor Loadings			
Premenstrual symptoms	**One**	**Two**	**Three**	**Four**
Depression	73	-	-	-
Aggressiveness	70	-	-	-
Confusion	70	-	-	-
Difficulty concentrating	64	-	-	-
Crying spell	57	-	-	-
Fatigue	50	-	-	-
Dizziness	39	-	-	-
Wish to be alone	39	-	-	-
Oily skin	-	75	-	-
Overeating	-	55	-	-
Acne	-	51	-	-
Pain in the thigh	-	-	76	-
Joint pain	-	-	73	-
Backache	-	-	69	-
Low appetite	-	-	43	-
Nausea	-	-	-	58
Diarrhoea	-	-	-	57
Sweating	-	-	-	56
Constipation	-	-	-	49
Reduced urine	-	-	-	42
Excessive sleep	-	-	-	36

Correlation determinant = 0.013, Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.819, Bartlett's test of sphericity P <0.001. All decimal points are omitted ***Factor 1:*** *Affective symtoms,* ***Factor 2:*** *Physical symptoms* ***Factor 3:*** *Somatic symptoms* ***Factor 4:*** *GIT/Physical symptoms*

having at least one symptom of PMS. From the graph, 42.1% reported that the symptoms are not severe while 27.1%, 17.5% and 13.3% reported having mild, moderate and severe symptoms respectively. Table 2 compares the blood pressures of participants at the follicular and luteal phases. Systolic and diastolic blood pressures and the mean arterial pressure at the luteal phase are significantly higher (P <0.001) than at

the follicular phase, pulse rate at the follicular phase is significantly (P <0.001) higher at the follicular phase than the luteal phase. Backache, wish to be alone, joint or muscle pain, fatigue, pain in the thigh, and acne/pimples are the six most severe and most commonly reported symptoms (Table 3). More than 50% of the subjects experienced the first eleven PMS symptoms. Most of these symptoms were affective symptoms.

Determination of Clusters of PMS

Table 4 showed the factor loadings, estimated separately for the four factors. Affective symptoms have the highest loadings while GIT/physical symptoms have the lowest symptoms. Depression correlated the most. The correlation decreases in the following order by aggressiveness, confusion, difficulty concentrating, crying spell, fatigue, dizziness, and wish to be alone. The Eigenvalues of factors one, two, three, and four are respectively 4.82, 1.59, 1.48, and 1.41. These four factors explained over 58% (not shown). Data reduction technique, Principal Component Analysis (PCA) starting with squared multiple correlations as the prior communality estimates to extract the principal factors from the 23 symptoms of PMS was performed. After performing preliminary Principal Factor Analysis of the symptom data and after rotation to allow for correlation between factors, four factors were identified using the criterion of the proportion of total variance explained. Sequel to rotation, factor 1 was an "affect" factor (high loadings from depression, aggressiveness, confusion, difficulty concentrating, crying spell, fatigue, dizziness, and wish to be alone). Factor 2 "were physical symptoms" (loading from oily skin, overeating, and acne). Factor 3 were "somatic symptoms" (loading from pain in the thigh, joint pain, backache, and low appetite). Factor 4 were "GIT/physical symptoms" (loading from nausea, diarrhoea, sweating, constipation, reduced urine, and excessive sleep). Symptoms of headache and sleeplessness did not load >3.0 on any of the four factors. Factors are extracted if their Eigenvalues are >1.0. The Eigenvalues of the fourth, third, and second factors are all >1 but substantially less than that for the first factor (4.81). Inter-factor correlations ranges from 0.03 to 0.37. Examination of the scree plot confirmed the appropriateness of selecting only one factor to explain the data.

DISCUSSION

Given the efforts made over the years to gain a better sense on the cause and possibly treatment of PMS and how much it affects the social and wellbeing of women that report suffering from it, over 89% (329) out of the 370 undergraduate students in our study reported experiencing at least one or more symptoms of PMS during each cycle. The findings in the present study is in keeping with previous studies in Nigeria (Antai *et al.*, 2004; Udezi and Ochei, 2014). This finding is also similar to that earlier reported by (Obeidat *et al.*, 2012) who reported a prevalence rate of 91.5% among Jordanian college students. Our result is also in keeping with previous findings (Angst *et al.*, 2001, Takeda *et al.*, 2006, Danborno and Oyibo, 2008; Victor *et al*., 2015). Derman and colleagues (2004) reported an incidence rate of 61.4% among Turkish adolescent girls and more recently, Cheng and colleagues (2013) reported an incidence rate of 39.85%.

The discrepancy in physiological state of subjects at follicular and luteal phase is striking. Their SBP, DBP, and mean arterial pressure at the menstrual phase are significantly higher than at the follicular phase (Table 3). These insights suggest the role of emotional state and endocrinological underpinnings of the subjects. Because the participants to this study were students, stress might also play a role in raising their BP.

Increased adrenaline increases the force of contraction of the heart and cardiac output. DBP decreases with increase in adrenaline by reducing total peripheral resistance. The association between anxiety and PMS has been reported previously (Gold *et al*., 2007; Obeidat *et al.*, 2012; Cheng *et al*., 2013). Both studies reported positive association between premenstrual anxiety and PMS.

However, there are other factors that were believed to cause symptoms of PMS that have also been associated with rise in BP such as excessive intake of salt and dairy products (Abdul-Razzak *et al.*, 2010). In addition to excessive salt intake and dairy products, other dietary intake that could contribute to higher BP are consumption of diets inadequate in vitamin D and calcium. Vitamin D and calcium have also been associated with the severity of PMS. The nexus between vitamin D and depression in women with PMS was unmasked by Bertone-Johnson in 2009. Calcium, a major component of bones and teeth and a micronutrient needed for blood clotting, proper functioning of heart and nervous has been implicated in severe PMS (Penland and Johnson, 1993; Thys-Jacobs *et al.*, 1998). The Dietary Approaches to Stop Hypertension (DASH, 2011) studies found significant reduction in BP of subject who consumed a low-fat diet rich in fruits and vegetables. For instance, Reed *et al*. (2008) found that women with PMS consume meals rich in fat than women without PMS. It is important to point out that BP at the menstrual phase may be influenced by symptoms of PMS such as emotional state or anxiety, and by many possible interacting lifestyle and dietary factors (though not accounted for in the present study).

In the present study, the 23 symptoms were clustered into four PMS factors namely; affective, physical, somatic, and GIT/physical factors. Symptoms, including depression, aggressiveness, confusion, and difficulty concentrating that have previously been

reported among affective symptoms of PMS (Danborno and Oyibo, 2008; Reiber, 2009; Obeidat *et al.*, 2012; Cheng *et al.*, 2013; Victor *et al*., 2015). Although previous studies have reported findings from several factor analyses of PMS, reported clusters or factors extracted are not in tandem according to the symptoms considered. The variance may be due to the symptoms included, study design (retrospective or prospective), sample population, age group, extraction method adopted (PCA, unweighted least squares, generalized least squares, etc.), factor analysis rotation among others (York *et al*., 1989; Boyle, 1992; Rivera-Tovar *et al*., 1992; Bancroft *et al.*, 1993; Condon, 1993; Bancroft, 1995; Mira *et al*., 1995; Freeman *et al*., 1996). Most other studies which findings are in consonant to ours also used prospective daily ratings of severity of symptoms (Gehlert *et al.*, 1999; Woods et al. 1999). Most single factor studies are retrospective in nature, combining an annual symptom experience rather than case-by-case consideration (Kendler *et al.*, 1992; Treloar *et al.*, 2002).

In conclusion, our findings indicate high prevalence rate of PMS. Blood pressure at late luteal phase of menstrual cycle is significantly higher than at the follicular phase. Backache, wish to be alone, joint or muscle pain, fatigue, pain in the thigh and acne/pimples are the six most commonly reported symptoms. Four factors or clusters (affective, physical, somatic and GIT/physical symptoms) explained data on the 23 symptoms of PMS.

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