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Decoding the Menstrual Health Exposome: An Integrated Multidimensional Assessment of Lifestyle, Dietary Patterns, Psychological Stress, Anthropometric Indices, and Reproductive Determinants of Menstrual Disorders in Young Women

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ABSTRACT

Background: Menstrual disturbances may reflect nutritional, anthropometric, and psychological determinants. This study evaluated menstrual characteristics and associations of menstrual patterns with dietary quality, body consumption, weight variation, and perceived stress.

Purpose: To evaluate menstrual health and its association with dietary, anthropometric, lifestyle, and psychological factors among young women

Methods: A multicenter analytical cross-sectional study was conducted among 314 menstruating women aged 15-30 years recruited from academic, healthcare, and community settings across Punjab, India. BMI characterized anthropometric status, and dietary quality was assessed using the Healthy Eating Assessment Tool (HEAT), and perceived stress using the Perceived Stress Scale (PSS). Associations were assessed using categorical tests.

Results: Participants had a mean age of 22.07 ± 2.91 years and mean age at menarche of 12.50 ± 1.28 years. Dysmenorrhea was reported by 40.8% of participants. BMI distribution comprised 18% underweight, 59% normal weight, 18% overweight, and 5% obese participants. Dietary quality was poor/fair in 40.5% and good/excellent in 59.6%. Dietary category was significantly associated with menstrual pattern ($p = 0.010$). Moderate or high stress affected 72%, and menstrual irregularity increased across low, moderate, and high stress categories (31.8%, 46.7%, and 56.8%, respectively; $p = 0.0124$). BMI and weight variation were also significantly associated with menstrual regularity.

Conclusions: Menstrual health reflects interactions between reproductive, metabolic, nutritional, and psychological factors. Poorer dietary quality, altered weight status or variation, and greater perceived stress were associated with less favourable menstrual patterns. Prospective multicenter studies across diverse Indian populations are warranted to establish temporality and evaluate the effectiveness of lifestyle interventions.

1. Introduction

Menstrual health is gradually recognized as a fundamental component of women's complete health and well-being, extending beyond reproduction to include physical, psychological, social, and metabolic health. The menstrual cycle is an extensive physiological process regulated through active interactions among the hypothalamic-pituitary-ovarian (HPO) axis, endocrine signaling networks, metabolic pathways, immune responses, and environmental revelation. Moreover, menstrual characteristics such as cycle length, bleeding patterns, regularity, and symptom severity are now considered essential indicators for female health status and reproductive competence. A recent global initiative has emphasized that menstrual health extends beyond menstrual hygiene and should be viewed as an integral module of sexual and reproductive health, public health, and women's rights (Hennegan *et al.*, 2021).

The menstrual cycle is regulated by the coordinated secretion of gonadotropin-releasing hormone (GnRH) from the hypothalamus, follicle-stimulating hormone (FSH) and leuteinizing hormone (LH) from the anterior pituitary, and ovarian steroid hormones, principally estrogen and progesterone. These endocrine signals coordinate follicular development, ovulation, endometrial proliferation, and menstrual shedding (Marques *et al.*, 2024). In general adult clinical guidance, a typical menstrual-cycle length is

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approximately 21-35 days, although age-specific variation should be considered when interpreting menstrual patterns in adolescents and young adults. Disruption of hypothalamic-pituitary-ovarian axis signalling may alter cycle frequency and reproductive function, contributing to menstrual disturbances (Liang *et al*., 2023).

Menstrual disorder comprises a heterogenous group of conditions, including dysmenorrhea, oligomenorrhea, amenorrhea, menorrhagia, polymenorrhea, irregular menstrual cycles, and premenstrual syndrome (PMS). These conditions collectively represent the most prevalent health concerns affecting women during their reproductive years. A recent review of two decades of evidence from India reported that the prevalence of menstrual disorders ranges from 3% to 87%; approximately 46-79% of women have dysmenorrhea and PMS, affecting 40-71% of women. Similarly, Das *et al*. (2024) identified dysmenorrhea as the most commonly reported menstrual disorder among Indian women and highlighted the extensive burden imposed by menstrual health problems on reproductive and general health (Das & Jungari, 2024).

The public health significance of menstrual disorders extends far beyond physical discomfort. Menstrual abnormalities have been associated with reduced quality of life, impaired academic performance, decreased productivity in the workplace, psychological distress, sleep disturbances, and adverse reproductive outcomes (Chattopadhyay *et al*., 2025; Shah *et al*., 2025). Continuous menstrual dysfunction may also represent an early clinical manifestation of endocrine disorders, metabolic dysfunction, insulin resistance, and chronic inflammatory distress. Therefore, menstrual disorders should not be viewed merely as isolated gynecological symptoms but rather as essential indicators of broader systemic dysregulation affecting women's health (Shukla *et al*., 2025).

Traditionally, menstrual disorders were investigated primarily from a gynaecological perspective, focusing on reproductive organs and hormonal dysregulations. However, collected evidence suggests that menstrual health is influenced by a complex connection between biological, behavioral, psychological, nutritional, and environmental factors. This model shift has given rise to the concept of menstrual health exposures on menstrual function and reproductive health. According to this framework, menstrual disorders emerge not from a single pathological factor but from interactions among nutrition, stress, and environmental exposures that collectively influence reproductive physiology (Odongo *et al*., 2023).

Among these considerations, psychological stress has emerged as one of the most influential yet unindicated contributors to menstrual dysfunction. The biological relationship between stress and menstrual health is primarily mediated through activation of the hypothalamic-pituitary-adrenal (HPA) axis. Chronic psychological stress exposure stimulates the secretion of corticotropin-releasing hormone (CRH) and cortisol, which can suppress hypothalamic GnRH dynamics and subsequently alter LH and FSH secretion. This neuroendocrine disruption may induce impairment in the development of follicles, ovulation, and production of progesterone, thereby contributing to menstrual irregularities, dysmenorrhea, amenorrhea, and PMS symptom exacerbation (Liu *et al*., 2024). Meta-analytic evidence represented that women experiencing higher levels of stress are significantly more likely to develop menstrual disorders than women with lower perceived stress levels. Furthermore, stress-related menstrual disturbance appears to be particularly pronounced among adolescents and young adults exposed to academic, social, occupational pressures (Kullik *et al*., 2024).

Nutritional status and dietary behavior are involved in another critical dimension of menstrual health. Sufficient nutrition is essential for maintaining energy homeostasis, steroid hormone synthesis, insulin sensitivity, and normal ovarian function. Emerging evidence indicates that modern dietary patterns characterized by high consumption of refined carbohydrates, processed foods, sugar or sweetened beverages, and saturated fats may adversely affect menstrual function through inflammatory, metabolic, and endocrine mechanisms (García-Montero *et al*., 2026). High-sugar and high-fat diets have been connected with elevation of systemic inflammation, altered insulin signaling, and disturbances in ovarian steroidogenesis; all these may contribute to dysmenorrhea, PMS, and menstrual irregularities. In contrast, high-nutrient dietary patterns rich in fruits, vegetables, whole grains, dietary fiber, and essential micronutrients appear to exert protective effects on reproductive health. Recent investigations have demonstrated that women with menstrual disorders frequently exhibit improper nutrient intake and significantly higher consumption of sugar-rich food and beverages, supporting the hypothesis that dietary behavior plays a central role in menstrual regulation (Ciebiera *et al*., 2021).

Anthropometric characteristic, particularly body mass index (BMI) and body weight difference, represent additional determinants of menstrual health. Adipose tissue is now considered an active endocrine organ that participates in estrogen metabolism, insulin regulation, inflammatory signaling, and sex hormone-binding globulin (SHBG) homeostasis. Excess adiposity contributes to hyperinsulinemia, increased androgen production, chronic low-grade inflammation, and altered estrogen metabolism; these can further interfere with ovulatory function and menstrual cyclicity (Marsh *et al*., 2023; Ginsburg, 2016). Conversely, undernutrition and excessive weight loss may

suppress hypothalamic reproductive signaling through energy deficiency and reduced availability of leptin. A meta-analysis that studies the relationship between obesity and menstrual disorder reported that obese women were significantly more likely to experience menstrual cycle abnormalities compared with women of normal weight. Multiple epidemiological studies have studied significant associations between increased BMI, obesity, and menstrual dysfunction (Athar *et al.*, 2024; Mazza *et al.*, 2024).

Lifestyle behaviors, including physical activity, sleep quality, sedentary behavior, and screen exposure, play an essential role in menstrual health. Poor sleep, physical inactivity, prolonged sedentary behavior, unhealthy dietary habits, and elevated stress levels have been interlinked with hormonal imbalance, metabolic disturbances, and an increased risk of menstrual irregularities, dysmenorrhea, and premenstrual symptoms. Although these factors have been widely studied, existing evidence remains fragmented, as most studies have examined them individually rather than exploring their combined influence on menstrual health. Moreover, limited research has accepted an integrated exposome-based approach to assess the cumulative effects of nutritional, psychological, lifestyle, anthropometric, and reproductive considerations, particularly among young women undergoing critical biological and psychological transitions (Alnaqbi *et al.*, 2025; Ju *et al.*, 2025). Despite increasing recognition of menstrual health as a multidimensional determinant of women's health, integrated evidence from young women across Punjab, India, remains limited, particularly regarding the combined contribution of nutritional, anthropometric, lifestyle, and psychological exposures. Therefore, this study aims to investigate the interplay of these factors to provide a more comprehensive understanding of the determinants of menstrual health and menstrual disorder among young women.

2. Method & Materials

2.1. Study Design

This study was designed as a multicenter analytical cross-sectional investigation study based on the menstrual health exposome, which indicates that menstrual health is controlled by the cumulative interaction of biological, psychological, nutritional, anthropometric, behavioral, and environmental exposures throughout the period of the reproduction process. Unlike conventional studies that investigate isolated risk factors, the present study indicates an integrated multidimensional outline to identify the combined association between dietary patterns and menstrual patterns, psychological stress, lifestyle behaviors, anthropometric characteristics, and reproductive determinants on menstrual disorders among young women across Punjab, India. The study was conducted following the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research to ensure methodological rigor, transparency, and reproducibility. Furthermore, operational definitions of menstrual disorders were standardized according to the recommendations of the International Federation of Gynecology and Obstetrics (FIGO) to maintain international comparability of menstrual health outcomes.

2.2. Study Setting

The study was conducted over a defined period of April 2025 to June 2026 across multiple universities, colleges, healthcare institutions, and selected community settings located in different districts of Punjab, India. The multicenter design was adopted to capture participants from diverse academic, healthcare, socioeconomic, and community backgrounds across the state and to improve geographical representation and external validity of the findings.

Data collections were carried out through both supervised in-person interactions and structured electronic questionnaires, depending on the accessibility of participants and institutional feasibility. All participating centers followed standardized data collection procedures to confirm uniformity across sites.

The study populations comprised apparently healthy menstruating females aged between 15 and 30 years, demonstrating adolescence and early reproductive adulthood. This age group was specifically selected due to the chronic hormonal, metabolic, behavioral, and psychological changes occurring during this period, which may significantly affect menstrual health outcomes.

Participants were selected from academic institutions, healthcare settings, and surrounding communities to capture a heterogenous population with varying socioeconomic, educational, and lifestyle backgrounds. This presents a broader, probably, representation of menstrual health patterns and associated determinants across different population subgroups.

2.3. Sample Size Determination

The minimum required sample size was estimated using Cochran's formula for prevalence studies:

$$n = Z^2 p(1-P) / d^2$$

Where,

n = Required sample size
Z = 1.96 corresponding to 95% confidence interval
P = Anticipated prevalence of menstrual disorders
d = Margin of error

Assuming an anticipated prevalence of menstrual disorder of 50%, a 95% confidence level, and a 5% absolute precision, the minimum required sample size was estimated at 384 participants using Cochran's formula. An additional 30-40% was initially considered to compensate for potential non-response and incomplete data, corresponding to a recruitment range of approximately 499-538 participants. Assuming an anticipated prevalence of menstrual disorder of 50%, a 95% confidence level, and 5% absolute precision, the minimum sample size was estimated at 384 participants using Cochran's formula. An additional 30-40% was initially considered to account for potential non-response and incomplete data, corresponding to a recruitment range of approximately 499-538 participants. However, 314 participants with complete eligible data were ultimately available for analysis. The study was therefore analyzed as an achieved-sample multicenter cross-sectional study. Because the achieved sample was below the originally calculated minimum, the study was not considered to have met the prespecified precision or sample-size target, and no claim of attainment of a predetermined statistical power was made.

2.4. Sampling Strategy

A multiphase stratified sampling strategy was employed to reduce selection bias and improve possible representation. Initially, participating institutions were stratified according to geographical locations and educational setting. Within each participating center, eligible participants were recruited through systematic random sampling.

Recruitment was conducted across participating centers during the prespecified study period; the final analyzable sample comprised all eligible participants who completed the study assessment and met the predefined data-completeness criteria.

2.5. Eligibility Criteria

2.5.1. Inclusion Criteria

Participants fulfilling all of the following criteria were considered eligible:

- Female participating aged 15-30 years
- History of spontaneous menstruation during the previous twelve months
- Menarche was attained at least two years prior to enrolment.
- Ability to understand the study questionnaire
- Provision of written informed consent before participation

2.5.2. Exclusion Criteria

Participants were excluded if they:

- Participants were pregnant or lactating
- Had attained menopause
- Had undergone hysterectomy or bilateral oophorectomy
- Participants were receiving hormonal replacement therapy or medications known to markedly modify menstrual function.
- Had chronic psychiatric disorder impairing reliable questionnaire completion
- Declined participation or submitted incomplete questionnaires

Chronic conditions diagnosed by physicians, such as polycystic ovary syndrome, thyroid disorders, diabetes mellitus, hyperprolactinemia, or other endocrine disorders, were not excluded, as these conditions represent important reproductive determinants. Instead, these variables were documented and adjusted for during multivariable analyses to minimize bias.

2.6. Study Development

Data were collected using a comprehensively developed questionnaire structured after an extensive review of published epidemiological studies, validated menstrual health instruments, and international reproductive health recommendations. The questionnaire includes modified components of the Menstrual Health Questionnaire (MHQ), Healthy Eating Assessment Tool (HEAT), and the Perceived Stress Scale (PSS-10), with additional validated domains included to overcome limitations associated with previous studies.

The questionnaire is based on seven major sections:

- Demographic and Socioeconomic Characteristics
- Reproductive and Menstrual History
- Anthropometric Characteristics
- Dietary Assessment
- Psychological Stress Assessment
- Lifestyle Behavior Assessment
- Medical and Gynecological History

Assessments of contents are validated by the specialists in obstetrics and gynecology, clinical pharmacy, epidemiology, nutrition, and biostatistics. The questionnaire underwent pilot testing among a representative group of participants to evaluate clarity, comprehensibility, response consistency, and completion before the commencement.

2.7. Data Collection Procedure

Data collection was conducted using a hybrid methodology consisting of supervised face-to-face interviews and secure electronic questionnaires to extend accessibility of participants while minimizing selection bias associated with online surveys. Following eligibility screening and

informed consent, participants completed the structured questionnaire under investigator supervision whenever possible. The trained investigator remained available to clarify questionnaire items without affecting responses of participants. Before data entry, immediate verification was performed after each completed questionnaire based on completeness and internal consistency.

2.8. Assessment of Menstrual Health

For the primary analysis of menstrual-cycle frequency, cycle length was defined as the interval between the first day of one menstrual period and the first day of the subsequent menstrual period. The study's operational classification of cycle length was prespecified as 21-35 days for the selected references category, with intervals outside the range classified separately. This operational defining was applied consistently when generating the menstrual-pattern outcome and conducting the corresponding association analyses.

2.9. Dietary Assessment

Dietary characteristics were evaluated using an additional Food Frequency Questionnaire adapted from the Healthy Eating Assessment Tool and Nutritional Assessment instruments. Participants reported the frequency of consumption of major food groups, including cereals, fruits, vegetables, legumes, dairy products, meat, fish, eggs, fast foods, fried foods, confectioneries, sugar-sweetened beverages, caffeinated beverages, ultra-processed foods, and energy drinks. Meal frequency, breakfast consumption, late night eating habits, water intake, and dietary supplement use were also recorded. Based on consumption frequency, an overall dietary quality score was evaluated, with higher scores that indicate healthier dietary patterns.

2.10. Assessment of Psychological Stress

Perceived psychological stress was assessed using the validated Perceived Stress Scale (PSS-10). Participants rated each item using a five-point scale ranging from 0, which indicates never, to 4, which indicates very often. Total scores ranged from 0 to 40, with higher scores representing greater perceived stress. Stress level was categorized into low, moderate, and high stress according to established scoring recommendations.

2.11. Lifestyle Assessment

Lifestyle variables include sleep duration, sleep quality, physical activity, sedentary behavior, recreational screen time, smoking status, alcohol consumption, and caffeine intake. Physical activity was assessed using the short version of the International Physical Activity Questionnaire (IPAQ-SF), whereas sleep quality was evaluated using selected components of the Pittsburgh Sleep Quality Index (PSQI). These variables were included due to growing evidence suggesting their significant contribution to endocrine regulation, circadian rhythm, metabolic homeostasis, and menstrual function.

Anthropometric measurements such as body weight, height, and waist circumference were obtained using calibrated instruments, and body mass index (BMI) was calculated to examine nutritional status. BMI is calculated as body weight in kilograms divided by the square of height in meters (kg/m^2). BMI status was classified using age-appropriate World Health Organization (WHO) criteria. Participants aged 15-19 years were classified using the WHO BMI-for-age reference for girls, based on age- and sex-specific standard deviation (SD) scores, whereas participants aged 20 years or older were classified using WHO adult BMI-for-age below -2 SD, normal BMI-for-age as -2 SD to +1 SD, overweight as above +1 SD to +2 SD, and obesity as above +2 SD. For adults, underweight was defined as BMI < 18.5 kg/m^2, normal weight as 18.5-24.9 kg/m^2, overweight as 25.0-29.9 kg/m^2, and obesity as BMI ≥ 30.0 kg/m^2. The age-appropriate BMI classification was used in the descriptive analysis and in assessing the association between BMI status and menstrual-cycle pattern.

2.12. Quality Assurance

Multiple quality assurance measures were conducted throughout the study. All investigators received standard training before participant recruitment and anthropometric assessment. A pilot study was conducted to evaluate questionnaire reliability and feasibility. Standard operating procedures were developed for data collection in each detail. Completed questionnaires examined with double verification before database entry. Double data entry and random database audits were performed to reduce transcriptional error, and missing values were systematically detected and verified prior to statistical analysis.

2.13. Outcome Measures and Statistical Measurement

The primary outcome of the study was the presence of menstrual disorders among young women, classified according to internationally accepted definitions proposed by the International Federation of Gynecology and Obstetrics (FIGO). Menstrual disorder assessments included dysmenorrhea, amenorrhea, oligomenorrhea, polymenorrhea, menorrhagia, hypomenorrhea, irregular menstrual cycles, and premenstrual syndrome (PMS). Participants presenting with one or more of these conditions were categorized as having menstrual disorders. The sensitivity and frequency of menstrual symptoms were also documented to provide a comprehensive assessment of the status of menstrual health.

Secondary outcomes measures included the identification of lifestyle, dietary, psychological, anthropometric, and reproductive determinants associated with menstrual disorders. Specifically, the study evaluated dietary quality, perceived psychological stress, body mass index (BMI), anthropometric characteristics, physical activity, sleep patterns, sedentary behavior, healthcare-seeking behavior, and abstinence from academic and occupational activities due to absenteeism. The relationships between these multidimensional determinants and menstrual health outcomes were investigated to identify modifiable risk factors and independent predictors of menstrual disorders.

All collected data were coded, verified, and entered into a secured electronic database prior to statistical analysis. This was done using the IBM Statistical Package for Social Science (IBM SPSS Statistics, Version 20). Prior to analyses, the dataset was examined for completeness, data entry errors, duplicate observations, and missing values. Continuous variables were assessed for normality using the Shapiro-Wilk test together with visual inspection of histograms and Q-Q plots. Normally distributed continuous variables were expressed as mean ± standard deviation (SD), whereas non-normally distributed variables were summarized as median with interquartile range (IQR). Categorical data were presented as frequencies and percentages.

Comparison between participants with and without menstrual disorder was performed using appropriate statistical tests according to the distribution of variables. The independent student's t-test was applied for normally distributed continuous variables, and the Mann-Witney U test was used for non-parametric data. Comparisons involving more than two groups were performed using ANOVA, and associations between categorical variables were evaluated using the chi-square test.

To determine independent predictors of menstrual disorders while controlling for potential confounding variables, multivariable binary logistic regression analysis was performed. Variables, demonstrating a significance level of $p<0.20$ in a single-variable analysis, together with clinically relevant variables identified from previous literature, were entered into the multivariable regression model. Adjusted odds ratios (AORs) with 95% confidence intervals (95% Cl) were calculated to quantify the strength of association between independent variables and menstrual disorders after adjustment for potential confounders, including age, socioeconomic status, BMI, dietary quality, psychological stress, physical activity, sleep characteristics, and relevant endocrine comorbidities.

Regression assumptions were evaluated before regression analysis. Multicollinearity among predictor variables was assessed using the Variance Inflation Factor (VIF) and statistics for tolerance, with VIF values greater than 5 considered indicative of significant multicollinearity. The goodness-of-fit of the final logistic regression model was assessed using the Hosmer-Lemeshow test, while the model discrimination was probably evaluated using the area under the receiver operating characteristic (ROC) curve (AUC). Missing data were examined prior to analysis, and only complete observations were included in the final regression models to maintain analytical reliability.

All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant. These analyses were used to characterize menstrual health outcomes and examine associations between menstrual patterns and nutritional, psychological, anthropometric, lifestyle, and reproductive characteristics while accounting for relevant covariates where appropriate.

3. Results

3.1. Participant Recruitment and Study Population

A total of 314 eligible young women completed the study questionnaire and met the predefined criteria for inclusion in the final analysis. Although the initial sample-size calculation indicated a minimum requirement of 384 participants, the achieved analyzable sample was 314 because recruitment did not reach the prespecified recruitment range. All completed questionnaires were screened for completeness and consistency, and only eligible participants with sufficiently complete data were included in the final analysis. The study population comprised menstruating females aged 15-30 years recruited across Punjab, India.

3.2. Baseline Demographic and Anthropometric Characteristic

The demographic characteristic of the study population is presented in Table 1. The mean age of the participants was 22.07 ± 2.91 years. The mean age at menarche was 12.50 ± 1.28 years.

BMI status was classified using age-appropriate WHO criteria to account for differences between adolescent and adult participants. BMI status was assessed using the categories currently reported in Table 1. Among the 314 participants, 55 (17.5%) were classified as underweight, 186 (59.2%) as normal weight, 56 (17.8%) as overweight, and 17 (5.4%) as obese. Normal weight was the most frequently reported category, followed by overweight and underweight, while obesity was reported in the smallest proportion of participants. The demographic and anthropometric distributions are illustrated in Figure 1.

Table 1: Baseline Demographic and Anthropometric Characteristic of the Study Population (n = 314)

Variables		**Frequency, n (%)**	**Mean ± SD**
Sample Size		314 (100)	-
Age (years)			22.07 ± 2.91
20-24 24-29 30-34	15-19	51 (16.2)	
	211 (67.2)		
	51 (16.2)		
	1 (0.3)		
Age at Menarche (year)			12.50 ± 1.28
11-14 Above 14	Below 11	13 (4.1)	
	241 (76.8)		
	60 (19.1)		
BMI Category	Underweight (<18.5 kg/m2)	55 (18)	
	Normal weight (18.5– 4.9 kg/m2)	186 (59)	
	Overweight (25.0-29.9 kg/m2)	56 (18)	
	Obese (≥30.0 kg/m2)	17 (5)	
Weight Variation	Weight Gain	78 (25)	
	Weight loss	32 (10)	
	No weight Variation	204 (65)	

Note: BMI status was classified using the WHO BMI-for-age reference for participants aged 15-19 years and WHO adult BMI cut-offs for participants aged 20 years or older. Percentage were calculated using the total study population (N=314).

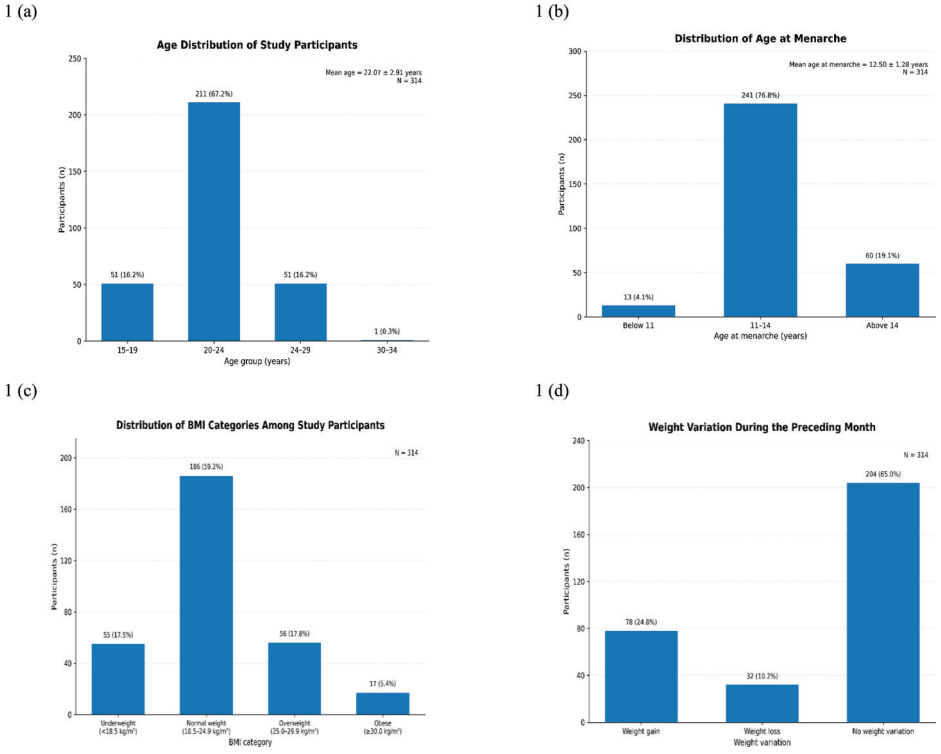


Figure 1: Baseline Demographic and Anthropometric Characteristics of the Study Population: (a) age distribution of study participants; (b) distribution of age at menarche; (c) distribution of BMI categories among study participants; and (d) weight variation during the preceding month.

3.2.1. Association of Anthropometric Characteristics with Menstrual Pattern

Anthropometric characteristics showed significant associations with menstrual pattern. Weight variation was strongly associated with menstrual pattern (p< 0.0001). BMI was also significantly associated with menstrual pattern (p = 0.0239) (Table 2). The summarized data is illustrated in Figure 2.

Table 2: Anthropometric Characteristic Association with Menstrual Pattern

Anthropometric Characteristic	Category	Regular Menstrual Cycle, n (%)	Irregular Menstrual Cycle, n (%)	Total (n)	p-value
Weight Variation	Weight Gain	36 (46.2)	42 (53.8)	78	<0.0001
	Weight Loss	15 (46.9)	17 (53.1)	32	
	No Weight Variation	146 (71.6)	58 (28.4)	204	
BMI category	Underweight	35 (63.6)	20 (36.4)	55	0.0239
	Normal Weight	125 (67.2)	61 (32.8)	186	
	Overweight	25 (44.6)	31 (55.4)	56	
	Obese	10 (58.8)	7 (41.2)	17	

Both anthropometric variables showed statistically significant relationships with menstrual pattern. Weight variation with menstrual irregularity approximately twice as frequent among participants reporting recent weight gain or loss compared with those reporting stable weight. BMI also showed a significant association, particularly among overweight participants, in whom irregular menstruation exceeded the proportion observed in the normal-weight group. Moreover, these findings show that recent weight fluctuation and BMI status were significant correlates of menstrual pattern disturbances in this population.

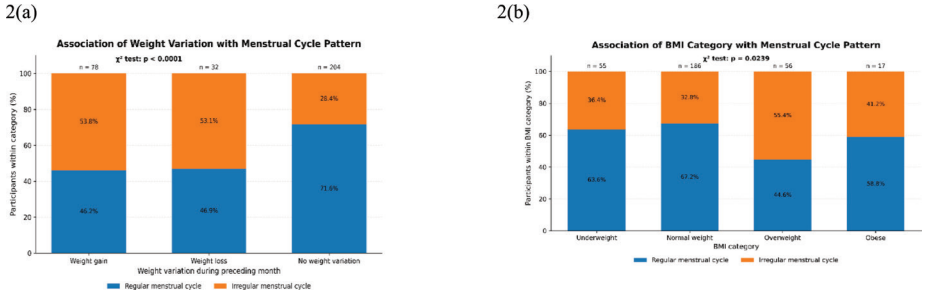


Figure 2: Association of Anthropometric Characteristics with Menstrual-Cycle Patterns: (a) association between weight variation during the preceding month and menstrual-cycle pattern; and (b) association between BMI categories and menstrual-cycle pattern.

3.3. Menstrual Characteristic of Study Population

The questionnaire evaluated multiple domains of menstrual health, including menstrual cycle length, duration of menstrual bleeding, menstrual flow characteristics, cycle regularity, and the occurrence of common menstrual disorders. The menstrual characteristics of the participants are presented in Table 3 and illustrated in Figure 3.

Most participants reported menarche during early adolescence, with menstrual cycle generally within the expected physiological range. However, considerable variability was observed in menstrual duration, cycle regularity, and menstrual flow characteristics. A substantial proportion of participants reported one or more menstrual abnormalities, highlighting the considerable burden of menstrual health problems among young women.

The most frequently reported menstrual effects were dysmenorrhea, followed by premenstrual syndrome (PMS). Additional menstrual disorders identified included irregular menstrual cycles, menorrhagia, hypomenorrhea, polymenorrhea, oligomenorrhea, and amenorrhea. These findings suggest that menstrual disorders are common within the study population and support the need to

investigate modifiable determinants associated with menstrual health.

Table 3: Menstrual Characteristic and Prevalence of Menstrual Disorders

Variable	Results
Total Participants	314
Age at Menarche (years), Mean	12.5
Premenstrual Syndrome (PMS), n (%)	314 (100%)
Dysmenorrhea, n (%)	128 (40.8%)
Irregular Menstruation, n (%)	116 (37%)
Oligomenorrhea, n (%)	94 (30%)
Hypomenorrhea, n (%)	88 (28%)
Amenorrhea, n (%)	79 (25%)
Menorrhagia, n (%)	41 (13%)
Hypermenorrhea, n (%)	41 (13%)
Polymenorrhagia, n (%)	22 (7%)

The assessment identified variation in menstrual characteristics and self-reported symptoms among the 314 participants. Menstrual pain severity was examined separately, with 128 (40.8%) participants reporting a great deal of pain, 178 (56.7%) reporting slight pain, and 8 (2.5%) reporting no pain. These findings indicate that menstrual pain of varying intensity was common in the study population. Premenstrual symptoms were also assessed individually, and their frequency distribution is presented in Table 9.

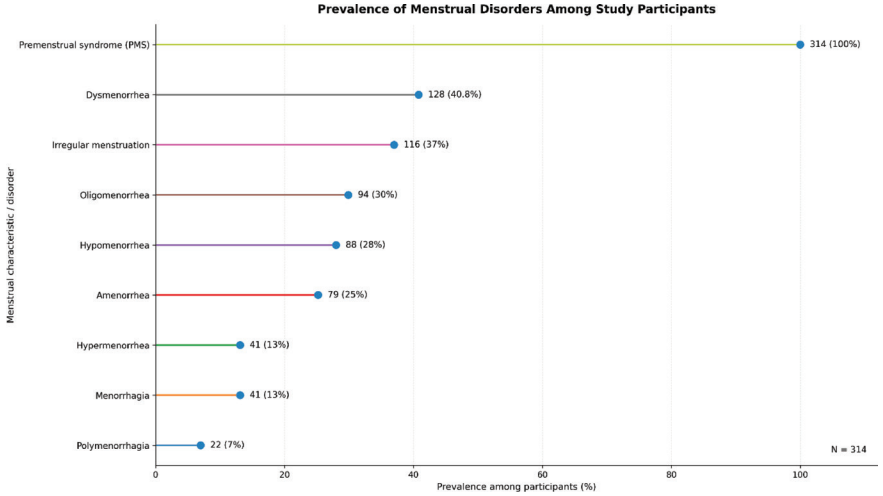


Figure 3: Distribution of menstrual characteristics and prevalence of menstrual disorders among the study population.

3.4. Characteristics of Menstrual Cycle Pattern

3.4.1. Age of Menarche

The age at menarche was assessed among all 314 participants as an important menstrual history characteristic. The mean age at menarche was 12.50 ± 1.28 years. Most participants (241, 76.8%) reported menarche between 11 and 14 years, while 60 (19.1%) experienced menarche after 14 years and 13 (4.1%) before 11 years. Thus, the study population was predominantly characterized by menarche occurring within the central adolescent age range between 11 and 14 years of age. The distribution is summarized as data represented in Table 4 and illustrated in Figure 4.

Table 4: Age at Menarche among study participants (N=314)

Age at Menarche (years)	Frequency (n)	Percentage (%)
Below 11	13	4.1
11 – 14	241	76.8
Above 14	60	19.1
Total	314	100.0
Mean ± SD	12.50 ± 1.28	-

3.4.2. Length of Bleeding During Menstrual Cycle

The duration of menstrual bleeding was assessed among the study participants and categorized as less than 4 days, 4-7 days, or more than 7 days. The study includes 186 participants (59%) who had bleeding for 4-7 days, considered the normal duration in the study, whereas 87 (27.7%) had bleeding for less than 4 days and 42 (13.4%) had bleeding for more than 7 days. Thus, approximately 41% of participants were reported to have an abnormal bleeding duration, comprising hypomenorrhea (<4 days) and hypermenorrhea (>7 days). The distribution of bleeding duration is summarized as data represented in Table 5 and illustrated in Figure 5.

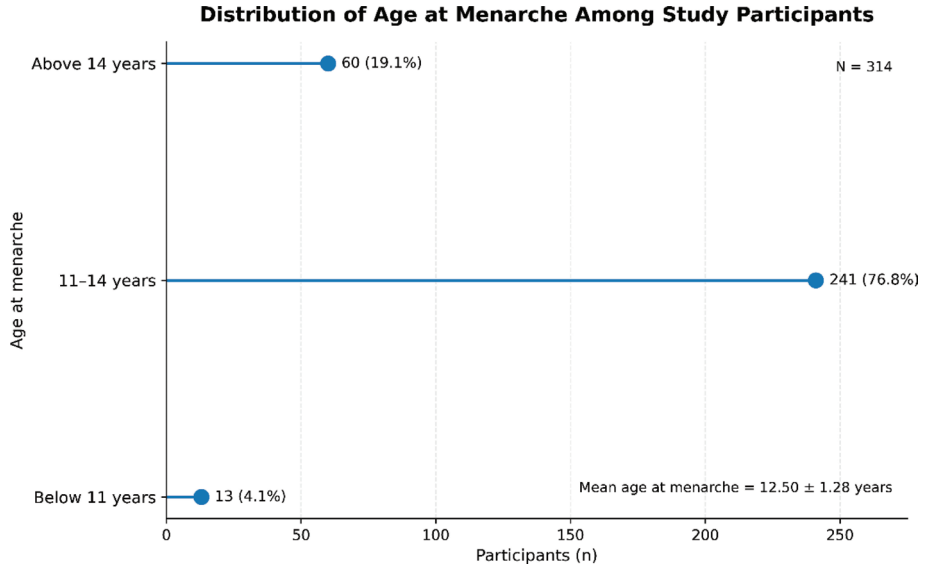


Figure 4: Distribution of Age at Menarche among Participants, showing the Predominant 11–14-year Age Group

Table 5: Distribution of Participants according to Length of Menstrual Bleeding

Length of Menstrual Bleeding	Interpretation	Frequency (n)	Percentage (%)
< 4 days	Hypomenorrhea	87	27.7
4 – 7 days	Normal Duration	185	59
> 7 days	Hypomenorrhea	42	13.4

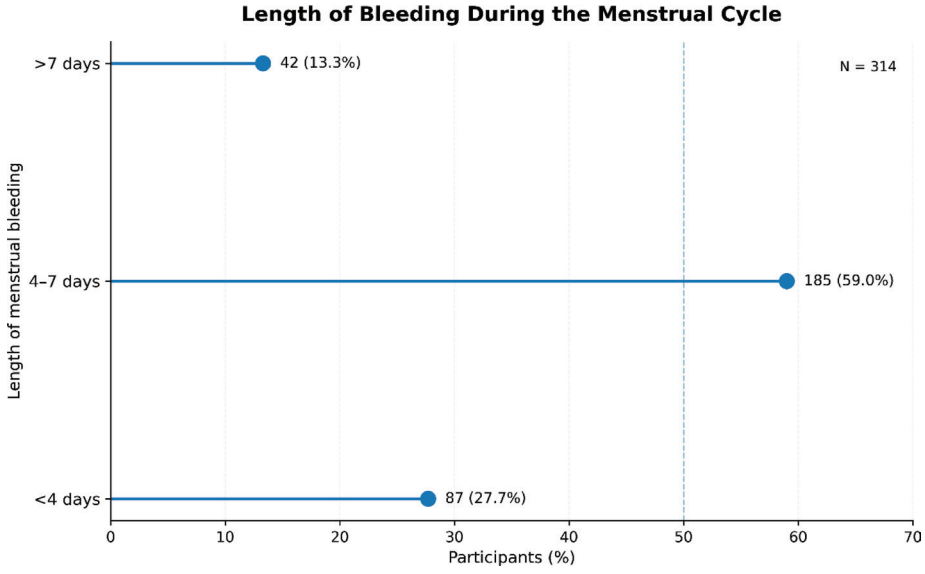


Figure 5: Distribution of Menstrual Bleeding Duration, Illustrating Normal and Abnormal Bleeding Patterns among Participants

Data representing abnormal bleeding duration represented a substantial proportion of the study population, with shorter-duration bleeding being more frequent than prolonged bleeding.

3.4.3. Percentage of Menstrual Flow in Participants

The distribution of menstrual flow among the 314 participants is presented in Table 6. Moderate menstrual

flow was predominant, occurring in 204 participants (65%), whereas 69 (22%) reported mild flow and 41 (13.1%) reported high menstrual flow. Thus, approximately eight participants reported heavy menstrual bleeding, representing a clinically relevant menstrual-flow abnormality in the study population. These menstrual-flow characteristics are summarized as data represented in Table 6 and illustrated in Figure 6.

Table 6: Distribution of Menstrual Flow Characteristics among Study Participants (N=314)

Menstrual Flow Category	Frequency (n)	Percentage (%)
Mild Menstrual Flow	69	22
Moderate Menstrual Flow	204	65
Heavy Menstrual Flow	41	13.1

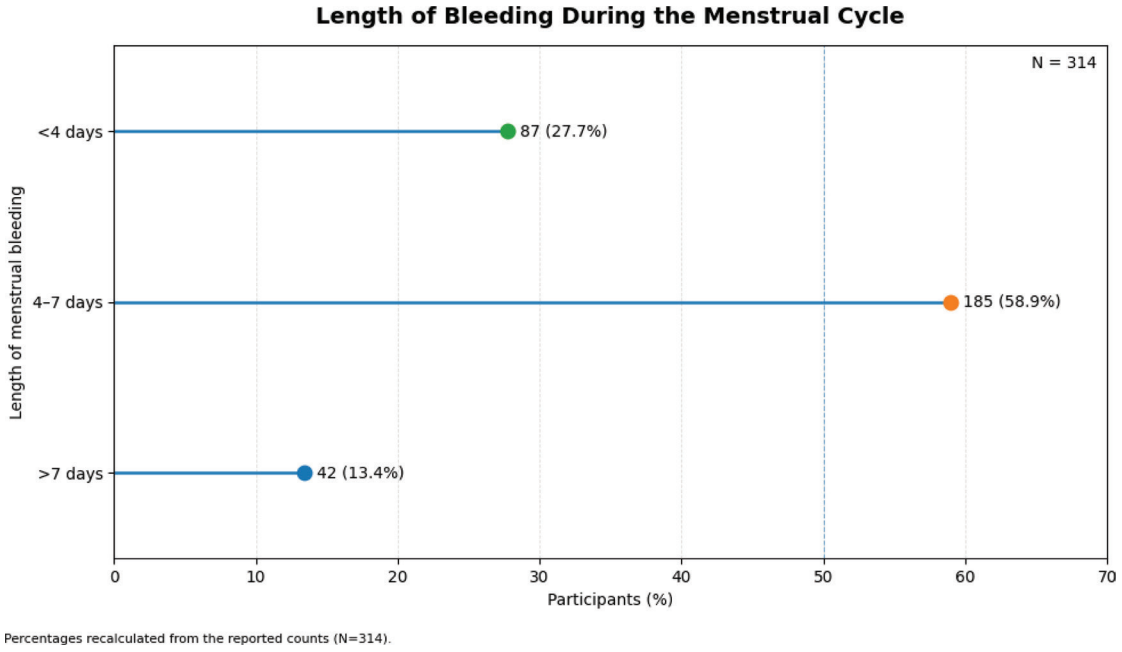


Figure 6: Distribution of Menstrual Bleeding Flow Characteristics among Participants

Moderate menstrual flow represented the predominant pattern, accounting for nearly two-third of participant, while 35% collectively reported either mild or heavy flow. In particular, 13.1% of participant had heavy menstrual flow describe menorrhagia.

3.4.4. Percentage of Menstrual Cycle Pattern of Participants in Past 12 Months

The frequency of menstrual cycle during the preceding 12 months was assessed among 314 participants. The majority, 197 (62.7%), reported 12 menstrual cycles/year, corresponding to a regular monthly pattern. In contrast, 93 (29.6%) participants reported less than 12 cycle/year, consistent with an oligomenorrheic pattern, while 24 (7.6%) reported more than 12 cycles/year, corresponding to a polymenorrhagic pattern. This, 117 participants (37.3%) had a cycle frequency different from the expected 12 cycle/year. The distribution is summarized as data represented in Table 7 and illustrated in Figure 7.

Table 7: Distribution of Menstrual Cycle in Participants during Last 12 Months

Menstrual Cycle Frequency	Interpretation	Frequency (n)	Percentage (%)
<12 cycles/year	Oligomenorrhea	93	29.6
12 cycles/year	Regular monthly menstruation	197	62.7
>12 cycles/year	Polymenorrhagia	24	7.6

3.4.5. Percentage Showing Menstrual Irregularity

The menstrual-cycle pattern was assessed over the preceding 12 months among 314 participants. A cycle interval of 21-35 days was considered regular, whereas all other reported intervals were classified as irregular. From the study population, 197 (62.7%) participants had a regular menstrual pattern, while 117 (37.3%) exhibited menstrua; irregularity. Among the irregular patterns, cycles occurring once every ≤21 days and 36-50 days were each reported by 41 (13.1%) participants, whereas 28 (8.9%)

reported cycles every 3-4 months and 7 (2.2%) had a very irregular pattern. The regular and irregular cycle-pattern categories are summarized as data represented in Table 8 and illustrated in Figure 8.

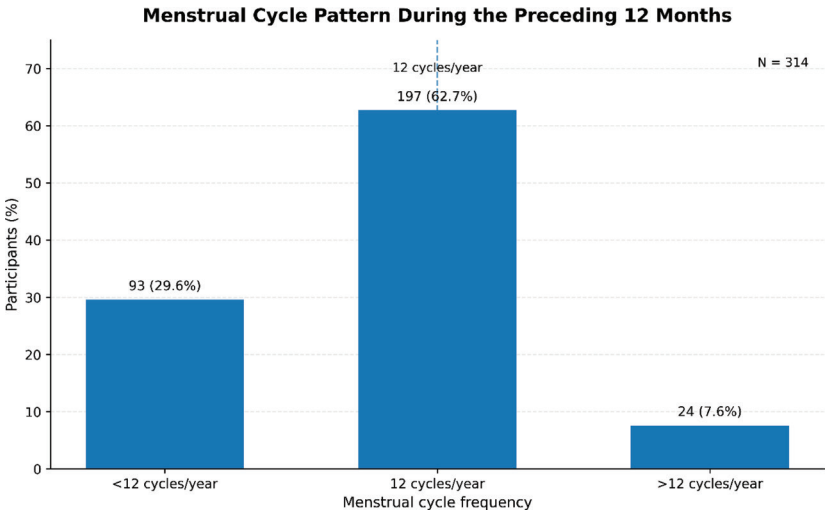


Figure 7: Distribution of Menstrual-Cycle Frequency during Preceding 12 Months

Table 8: Distribution of Menstrual Cycle Pattern among Study Participants (N=314)

Menstrual-Cycle Interval/Pattern	Classification	Frequency (n)	Percentage (%)
Once Every ≤ 21 days	Irregular	41	13.1
21 – 35 Days	Regular	197	62.7
36 – 50 Days	Irregular	41	13.1
Every 3 – 4 Months	Irregular	28	8.9
Very Irregular	Irregular	7	2.2

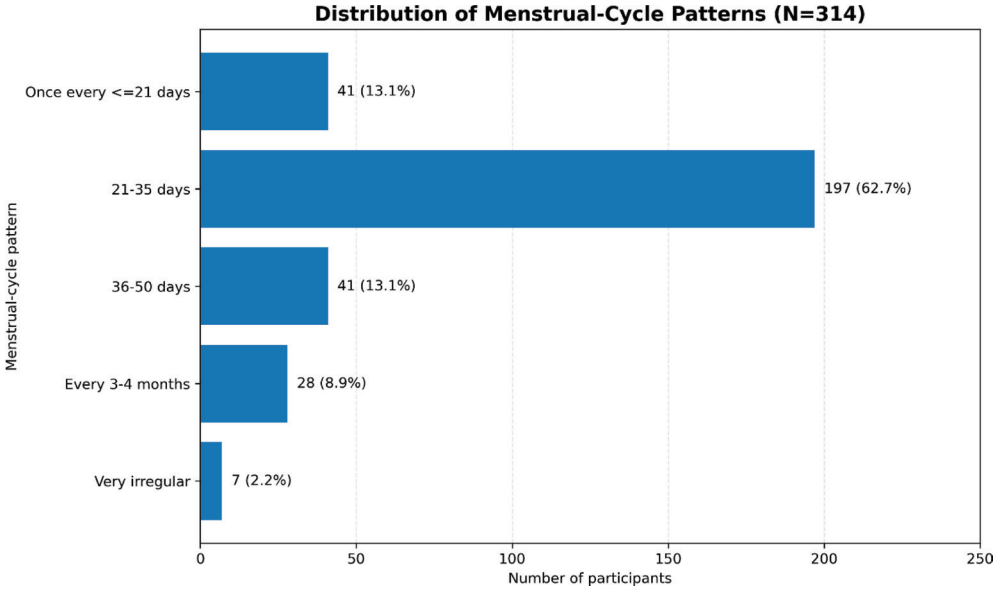


Figure 8: Distribution of Regular and Irregular Menstrual-Cycle Patterns among Study Participants, Demonstrating the Prevalence of Menstrual Irregularity

The data indicate that approximately one in three participants (37.3%) had an irregular menstrual pattern, while nearly two-thirds (62.7%) had a regular 21–35-day cycle. This establishes menstrual irregularity as a substantial outcome in the study population and provides the primary outcome distribution for subsequent association analyses with anthropometric, dietary, and psychological characteristics.

3.4.6. Pre-Menstrual Syndrome in Participants

Among 314 participants, 31 premenstrual symptoms were assessed. The most frequently reported symptoms were stomach pain and mood swings (167; 53% each), followed by headache (133; 42%), changes in energy (101; 32%), hair loss (95, 30%), food craving (88; 28%), anxiety and feeling depressed (84 and 85; 27%), and muscle pain (83; 26%). Sleeping difficulties, frequently feeling tired, and absent menstrual periods were each reported by 78 (25%) participants. Other symptoms occurred at lower frequencies with taste changes being least common (12, 4%). The symptom frequencies are summarized as data represented in Table 9 and illustrated in Figure 9.

Table 9: Frequency and Distribution of Premenstrual Syndromes among Study Participants (N=314)

Premenstrual Symptoms	**Frequency (n)**	**Percentage (%)**
Stomach Pain	167	53
Mood Swings	167	53
Headaches	133	42
Changes in Energy	101	32
Hair Loss	95	30
Food Craving	88	28
Feeling Depressed	85	27
Anxiety	84	27
Muscle Pain	83	26
Frequently Tired	80	25
Absent Menstrual Periods	78	25
Sleeping Difficulties	78	25
Dizziness	72	23
Episodes of Crying for “no reason”	70	22
Difficulty Concentrating	69	22
Breast Pain	54	17
Less Social Interaction with Family	49	16
Fainting	47	15
Confusion	47	15
Skin Changes	48	15
Joint Pain	44	14
Tingling Sensation in Hands or Feet	38	12
Diarhhea	35	11
Difficulty in Making Decisions	35	11
Hair Growth on Face and/or Chest	34	11
Constipation	31	10
Cold Intolerance	27	9
Changes in Urination	29	9
Obsessive-Compulsive Behaviour	20	6
Taste Changes	12	4

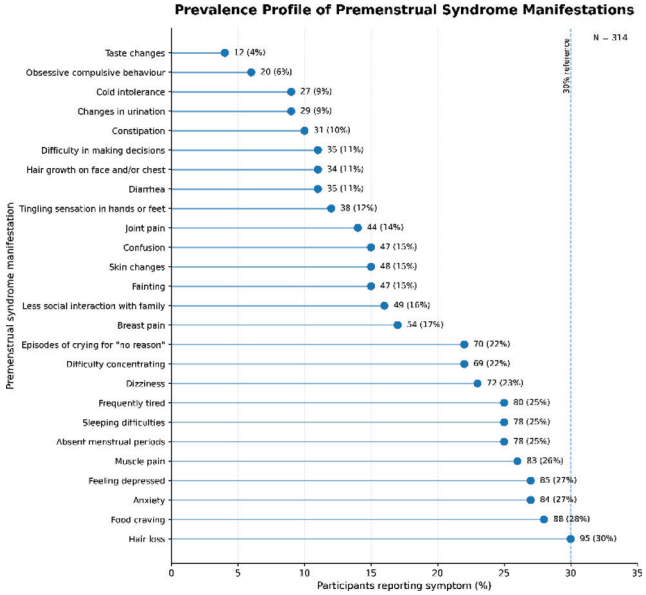


Figure 9: Frequency Distribution of Premenstrual Syndrome Symptoms among Participants Highlighting the Most Frequently Reported Somatic, Emotional and Psychological Manifestations

Overall, the findings indicate that PMS in this population was characterized predominantly by somatic, emotional, and psychological symptoms, with gastrointestinal discomfort and mood disturbances being the most prominent manifestations.

3.4.7. Percentage of Dysmenorrhea Among Participants

Among the 314 participants, 128 (40.8%) were classified as having dysmenorrhea according to the study assessment. Regarding the severity of self-reported menstrual pain or cramps, 128 (40.8%) participants reported a great deal of pain, 178 (56.7%) reported slight pain, whereas 8 (2.5%) reported no menstrual pain. Thus, dysmenorrhea affected 40.8% of the study population, while menstrual pain of varying intensity was reported more broadly across the cohort. The distribution of self-reported pain severity is summarized as data represented in Table 10 and illustrated in Figure 10.

Table 10: Distribution of Self-Reported Menstrual Pain/Cramp Severity among Study Participants (N=314)

Severity of Menstrual Pain/Cramps	Frequency (n)	Percentage (%)
Great deal	128	40.8
Slightly	178	56.7
Not at all	8	2.5

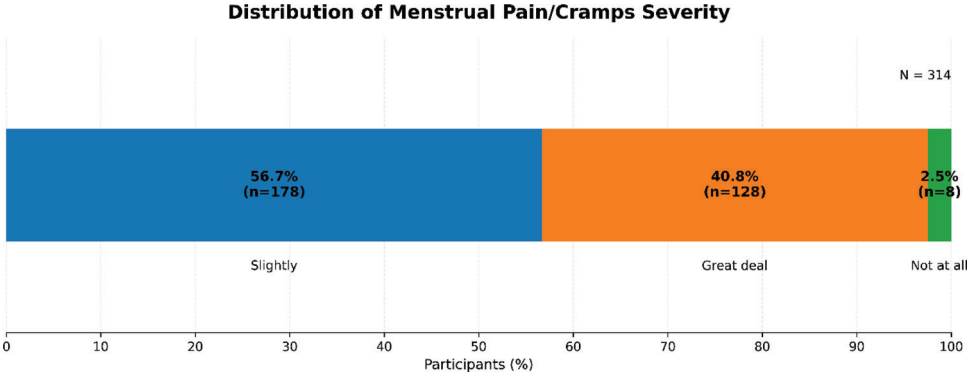


Figure 10: Distribution of Dysmenorrhea Severity among Participants According to the Reported Intensity of Menstrual Pain and Cramps

3.5. Dietary Characteristics

Dietary habits of the study participants were assessed using the Healthy Eating Assessment Tool (HEAT), which was employed to investigate the overall quality of dietary practices and categories of participants according to their eating behavior. The assessment included the frequency of consumption of major foods and dietary practices that may influence menstrual health as represented in Table 11.

The HEAT assessment demonstrated variability in dietary patterns among the participants that indicates the study population comprised individuals with differing levels of diet habits. Participants with lower HEAT scores exhibited poorer dietary habits, whereas higher scores reflected healthier dietary practices.

Comparative analysis revealed a statistically significant association between dietary habits and menstrual irregularity ($p = 0.01$), suggesting that dietary quality was significantly associated with menstrual health in the study population. Participants with low dietary habits were more frequently represented among those reporting menstrual irregularities than participants with healthier dietary patterns. These findings support the hypothesis that nutritional behavior is an important modifiable determinant of menstrual health and justify the inclusion of dietary assessment as one of the principal exposure variables in the study.

Table 11: Assessment of Dietary Habis Using HEAT score

HEAT Score Category	Frequency (n)	Percentage (%)
Need Improvement	79	25.2
Fair eating habits	48	15.3
Good eating habits	85	27.1
Excellent eating habits	102	32.5
Total	314	100.0

Note: Percentages were calculated from the frequencies using N=314

Among the 314 participant, 102 (32.5%) showed excellent dietary habits representing the largest dietary category. Good dietary habits were observed in 85 (27.1%) participants, whereas 79 (25.2%) participants required dietary improvement according to the HEAT assessment. Fair dietary habits were identified in 48 (15.3%) participants, representing the smallest proportion of the study population. Overall, approximately 60% of the participants exhibited good-to-excellent dietary practices, while nearly 40% represented suboptimal dietary behaviors requiring nutritional improvement.

3.5.1. Association of Dietary Habits with Menstrual Patterns

Statistically significant association between dietary habits, assessed using the HEAT and menstrual cycle pattern (p= 0.010). The association results are summarized as data represented in Table 12 and illustrated in Figure 11.

The findings show a clear inverse pattern between dietary quality and menstrual irregularity, participant with poorer dietary habits had markedly higher frequencies of irregular menstruation, whereas all participants classified as having excellent eating habits had regular menstrual cycles. The significant association (p=0.010) indicates that dietary habit category was significantly related to menstrual pattern in this study population.

Table 12: Dietary Habits Association with Menstrual Irregularity

HEAT dietary category	Regular menstrual cycle, n (%)	Irregular menstrual cycle, n (%)	Total (n)
Need Improvement	6 (7.6)	73 (92.4)	79
Fair eating habit	12 (25.0)	36 (75.0)	48
Good Eating habit	78 (91.8)	7 (8.2)	85
Excellent eating habit	102 (100.0)	0 (0.0)	102
Total	198 (63.1)	116 (36.9)	314
p-value	-	-	0.010

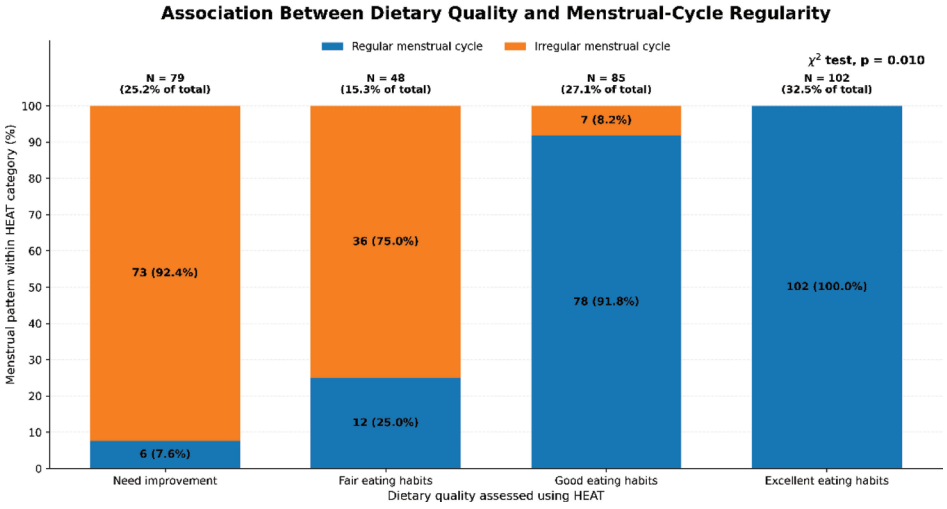


Figure 11: Association between HEAT-defined dietary quality and menstrual-cycle pattern demonstrating greater menstrual irregularity among participants with poorer dietary habits.

3.6. Assessment of Psychological Stress

Psychological stress was examined using the Perceived Stress Scale (PSS) among the 314 study participants. The study classified participants into three stress categories with low, moderate, and high stress and reported the corresponding frequency distribution in Table 13.

Table 13: Distribution of Perceived Psychological Stress among Study Participants according to PSS (N=314)

PSS Stress Category	Frequency (n)	Percentage (%)
Low Stress	88	28
Moderate Stress	182	58
High Stress	44	14
Total	314	100

The largest proportion of participants belonged to the moderate-stress category (182/314; 58%), 9followed by participants with low stress (88/134; 28%) and high stress (44/314; 14%). Thus, 226 participants (72%) were classified as having moderate or high perceived stress, whereas only 88 (28%) were categorized as having low stress. The study therefore indicates that perceived psychological stress was common in this study population, with moderate stress representing the predominant category.

3.6.1. Association between Perceived Stress and Menstrual Pattern

Further study between PSS-defined stress categories and menstrual cycle pattern. The average result showed a progressive shift towards menstrual irregularity across the higher stress categories. Among participants with low stress, 60 had a regular menstrual pattern and 28 had an irregular pattern. In the moderate-stress groups, 97 participants had regular cycles and 85 had irregular cycles, while among those with high stress, 19 had regular and 25 had irregular menstrual cycles. The association between perceived stress and menstrual-cycle pattern is summarized as data represented in Table 14 and illustrated in Figure 12.

Table 14: Perceived Stress Association with Menstrual Cycle Pattern

PSS Stress Category	Regular Menstrual Cycle (n)	Irregular Menstrual Cycle (n)	Total (n)	Irregularity (%)
Low Stress	60	28	88	31.8
Moderate Stress	97	85	182	46.7
High Stress	19	25	44	56.8
Total	176	138	314	43.9

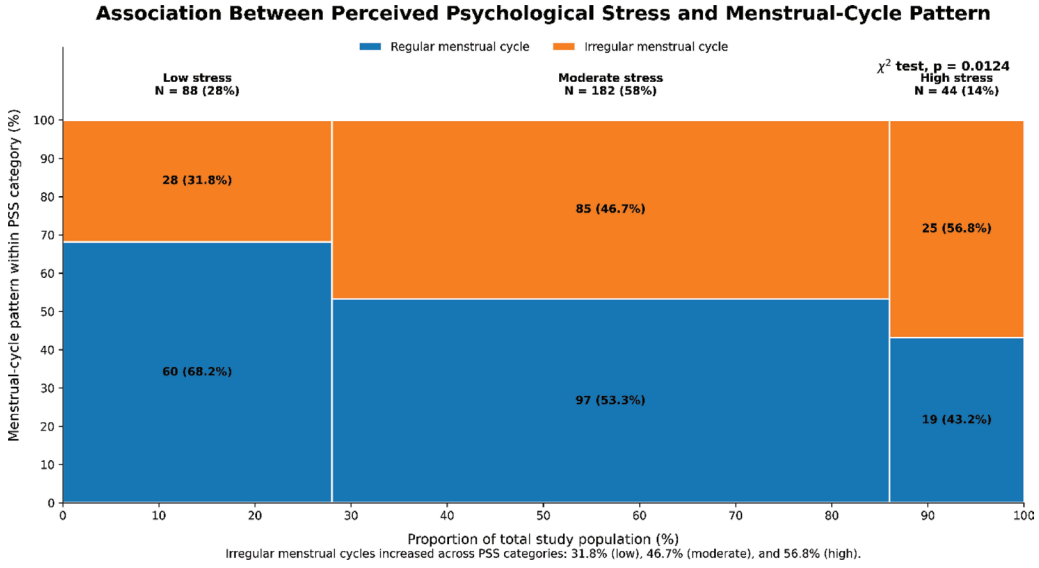


Figure 12: Association between Perceived Psychological Stress and Menstrual-Cycle Pattern, Demonstrating a Progressive Increase in Menstrual Irregularity across Increasing PSS Stress Categories

A statistically significant association was observed between perceived stress and menstrual pattern (p= 0.0124). The significant trend indicates that higher perceived stress was associated with a greater proportion of menstrual irregularity, with the highest prevalence observed among highly stresses participants.

4. Discussion

The present study provides a multidimensional assessment of menstrual health among 314 adolescents and young adults, representing that menstrual disturbances coexist with potentially modifiable nutritional, anthropometric, and psychological factors. The cohort was predominantly young adults (mean age, 22.07 ± 2.91 years), with a mean age at menarche of 12.50 ± 1.28 years; 76.8% reported menarche between 11 and 14 years. This distribution is broadly consistent with the expected timing of menarche and provides a relatively homogenous reproductive-age population for evaluating menstrual factors.

A substantial burden of menstrual symptoms was observed. The manuscript identified dysmenorrhea, irregular menstruation, oligomenorrhea, hypomenorrhea, and amenorrhea among the principal menstrual abnormalities. This is similar to evidence from the large systematic reviews showing that dysmenorrhea is highly prevalent among young women. A meta-analysis involving 21,574 young women estimated an overall dysmenorrhea prevalence of 71.1%, with university students showing similarly high prevalence (Armour *et al.*, 2019). Thus, the substantial symptomatic

burden observed in this cohort is clinically plausible and emphasizes that menstrual disorders represent more than an isolated gynecological complaint; they can interfere with education, daily functioning, and quality of life. In the present study, dysmenorrhea was observed in 40.8% of participants (128/314). Although a larger proportion of participants reported some degree of menstrual pain or cramps, these responses were not equated with the operational classification of dysmenorrhea. Accordingly, dysmenorrhea prevalence was reported separately from the broader distribution of menstrual pain severity.

Anthropometric status was evaluated using age-appropriate WHO BMI classification criteria to account for differences between adolescent and adult participants. In this cohort, 18% were underweight, 59% normal weight, 18% overweight, and 5% obese. Recent weight gain or loss was also reported by 25% and 10% of participants, respectively. Both weight variation and BMI were significantly associated with menstrual pattern ($p < 0.0001$ and $p = 0.0239$, respectively). The particularly high proportion of irregular cycles among participants reporting recent weight gain or loss represents that dynamic changes in energy balance may be relevant in addition to static BMI. However, existing evidence indicates that BMI-menstrual associations are complex. A meta-analysis of 29,647 participants found that underweight status was associated with increased odds of primary dysmenorrhea (OR 1.43, 95% CI 1.18 – 1.73), whereas overweight and obesity were not consistently associated. Therefore, the present BMI findings should be interpreted as associations rather than evidence of a direct causal effect.

Dietary quality showed a special association with menstrual regularity. Only 15.3% of participants were classified as having fair eating habits, and 25.2% required dietary improvement, whereas 27.1% and 32.5% had good and excellent dietary habits, respectively. More importantly, irregular menstruation occurred in 92.4% of participants requiring dietary improvement and 75.0% of those with fair dietary habits, compared with only 8.2% among participants with good dietary habits and none among those with excellent dietary habits ($p = 0.010$). This data is biologically plausible because dietary composition can influence inflammatory pathways, micronutrient availability, and metabolic-endocrine signalling. A 2024 cross-sectional study similarly reported poorer dietary quality and greater consumption of high-sugar foods among women with menstrual disorders (Güzeldere *et al.*, 2024). A 2026 systematic review further concluded that greater fruit and vegetable consumption and lower intake of inflammatory/Western dietary patterns may be associated with reduced dysmenorrhea risk, although the authors emphasized limitations in the existing evidence (Sergio *et al.*, 2026).

Psychological stress demonstrated another clear gradient. Moderate or high perceived stress affected 72% of participants, and menstrual irregularity increased from 31.8% in the low-stress group to 46.7% and 56.8% in moderate- and high-stress groups, respectively ($p = 0.0124$). This finding is strongly supported by a 2024 systematic review of 41 studies, in which most studies reported an association between psychological stress and dysfunctional menstruation (Poitras *et al.*, 2024). More recently, a meta-analysis of 66 studies involving 38,344 participants demonstrated a positive association between stress and premenstrual symptom severity ($r = 0.29$, 95% CI 0.23-0.36) (Bencker *et al.*, 2025). A recent study in young Indian women likewise found higher menstrual irregularity among women with higher perceived stress (Awasthi, 2025). Mechanistically, stress may influence hypothalamic-pituitary-ovarian signalling through altered HPA-axis activity and stress-mediated disruption of pulsatile GnRH secretion, providing a plausible biological explanation for the observed gradient.

Collectively, these findings support a biopsychological model of menstrual health, in which nutritional quality, weight dynamics, and psychological stress may interact rather than operate independently. The manuscript appropriately planned multivariable logistic regression to account for age, socioeconomic status, BMI, dietary quality, psychological stress, physical activity, sleep, and endocrine comorbidities. This is important because the observed unadjusted associations cannot establish independent effects or causality.

Several limitations should be further studied in future. The achieved sample size was smaller than the originally calculated minimum of 384 participants, which may have reduced statistical precision and limited the power to detect smaller associations, particularly in subgroup analyses. The cross-sectional observational design limits the ability to establish causal relationships, while the use of self-reported questionnaire data may introduce recall and reporting bias. The study was also conducted in a relatively specific young population setting, which may limit the generalizability of the findings to other age groups and populations. Additionally, residual confounding from factors such as physical activity, sleep, socioeconomic status, medication use, and underlying endocrine or gynaecological conditions cannot be completely excluded. Future prospective, multicenter studies with objective measurements and longitudinal follow-up are therefore warranted to validate these associations and better establish their temporal and causal relationships.

5. Conclusion

This study demonstrates that menstrual health in young women is a multidimensional outcome influenced by

interacting biological, nutritional, and psychological factors. A substantial burden of menstrual morbidity was observed, with dysmenorrhea and menstrual-cycle disturbances representing prominent concerns. The present findings further identify modifiable correlates of menstrual-pattern disturbance. Significant associations of BMI and recent weight variation with menstrual regularity suggest that reproductive function may be sensitive to body composition and changes in energy balance. Meta-analytic evidence similarly links low VMI with increased risk of primary dysmenorrhea, although associations across BMI categories remain heterogeneous. Dietary quality was significantly associated with menstrual pattern, with poorer HEAT-defined dietary categories showing greater probable representation of regular menstruation. Nutritional status may influence reproductive health through metabolic homeostasis, inflammatory signalling, and endocrine regulation, while systematic evidence supports an association between dietary practices and menstrual symptoms, although intervention evidence remains limited. Psychological stress showed a progressive association with menstrual irregularity across increasing PSS categories. This supports a plausible neuroendocrine pathway involving interacting between the hypothalamic-pituitary-adrenal and hypothalamic-pituitary-ovarian axes, through which sustained stress may alter reproductive hormonal regulation. Overall, the findings support an integrated biopsychosocial framework for menstrual health and identify dietary improvement, weight stability, and stress management as promising preventive targets.

Abbreviations

BMI: Body Mass Index; **PMS:** Premenstrual Syndrome; **MHQ:** Menstrual History Questionnaire; **FSH:** Follicle-Stimulating Hormone; **GnRH:** Gonadotropin-Releasing Hormone; **HPA:** Hypothalamic-Pituitary-Adrenal; **PCOS:** Polycystic Ovary Syndrome; **SSRI:** Selective Serotonin Reuptake Inhibitor; **SHBG:** Sex Hormone-Binding Globulin; **CI:** Confidence Interval; **WHO:** World Health Organization; **HEAT:** Healthy Eating Assessment Tool; **PSS:** Perceived Stress Scale; **SPSS:** Statistical Package for the Social Sciences; **LH:** Luteinizing Hormone; **HPO:** Hypothalamic-Pituitary-Ovarian; **CRH:** Corticotropin-Releasing Hormone; **PMDD:** Premenstrual Dysphoric Disorder; **NSAIDs:** Nonsteroidal Anti-Inflammatory Drugs; **MPA:** Medroxyprogesterone Acetate; **SD:** Standard Deviation; **OR:** Odds Ratio; **HPO axis:** Hypothalamic-Pituitary-Ovarian Axis.

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Authorship Contribution

Soumarshi Das contributed to conceptualization, methodology, data curation, experimentation, investigation, resources, and writing of the original draft. Sarita Jangra contributed to visualization, validation, formal analysis, project administration, and writing, including review and editing of the manuscript.

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Conflict of Interest

The authors declare that they have no conflicts of interest or competing interests related to this work.

Declaration

The authors affirm that this manuscript is original, has not been published previously, and has not been plagiarized. All authors have read and approved the final manuscript and take full responsibility for the accuracy, integrity, and originality of its contents.

Ethical Approval

The protocol was approved by Institutional Human Ethics Committee Chitkara University (IHEC/DHR/CU/PB/23/255a).

Human and Animal Rights

No animals were used in this research. All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee

Data Availability Statement

The authors confirm that the data supporting the conclusions of this study are included within the article.

Figure Permission

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AI Disclosure Statement

The authors confirm that any use of artificial intelligence-assisted tools was limited to language editing and manuscript preparation support. The authors take full responsibility for the accuracy, integrity, and originality of the manuscript.

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