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Original Research Article

Association of Body Mass Index with Age at Menarche and Menstrual Characteristics in Young Females

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Abstract:

Background: Body Mass Index (BMI) plays a crucial role in reproductive health and may influence age at menarche and menstrual characteristics. Extremes of BMI are associated with hormonal imbalance and menstrual irregularities.

Aim: To assess the association of BMI with age at menarche and menstrual characteristics among young females.

Methodology: A hospital-based cross-sectional analytical study was conducted among 140 unmarried females aged 17–25 years at Department of Obstetrics and Gynaecology, Nalanda Medical College and Hospital, Patna, Bihar, India. Data were collected using a structured questionnaire and anthropometric measurements. BMI was calculated and categorized. Statistical analysis included Chi-square test and independent sample t-test, with $p < 0.05$ considered significant.

Results: The mean age at menarche was 13.21 ± 1.24 years and mean BMI was 22.18 ± 3.12 kg/m². Most participants (61.4%) had normal BMI. Menstrual irregularity was observed in 22.9% and was significantly higher among underweight (50%) and overweight (42.3%) participants compared to normal BMI (9.3%) ($p < 0.001$). Higher BMI was significantly associated with earlier menarche ($p = 0.002$).

Conclusion: BMI is significantly associated with age at menarche and menstrual patterns. Maintaining normal BMI may promote optimal reproductive health.

Keywords: Body Mass Index, Age at Menarche, Menstrual Characteristics, Menstrual Irregularity, Young Females.

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Introduction

Menstruation is generally considered to be a hall-mark physiological characteristic of femininity and fertility. Menstruation and menses derive their names not only from the Latin menses (month), but also the Greek word Mene (moon) and the English word month, indicating the lunar cycle of around 28 days (27.32 days). Menstrual cycle is complicated and cyclic interplay of hypothalamo–pituitary–ovarian (HPO) axis, which leads to recurrent shedding of endometria when not pregnant. Normal menstruation is regarded as a significant sign of the general reproductive and endocrine wellbeing of young females.

A number of physiological and environmental conditions dictate how often, how long and how much the menstrual cycle occurs. Among them, hormonal balance, genetic disposition, nutrition status, underlying medical conditions, psychological stress, and body composition are very vital. Over the last few years, body mass index (BMI) has become one of the strongest predictors of menstrual health. High and low BMI have been linked to such disturbances as amenorrhea, oligomenorrhea, irregular cycles, and dysmenorrhea [1,2]. Adipose tissue is not a passive organ of fat storage but is a dynamic endocrine organ modulating estrogen metabolism, insulin resistance, and inflammatory processes having direct effects on ovulatory activity and menstrual cyclicity.

Periodal abnormalities and anovulation have been reported to be more frequent in women that are very far off the normal weight. Body mass extremes, either underweight or overweight, may interfere with the normal pulsatile secretion of the gonadotropin-releasing hormone (GnRH), which results in the

secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) in abnormal amounts, which eventually affects ovulation. Some of the studies have also indicated that greater grades of obesity have a positive correlation with greater likelihoods of abnormal menstruation [3]. Obesity helps cause hyperinsulinemia and overproduction of peripheral androgens to estrogens leading to hormonal disturbance which could be manifested as abnormal menstrual bleeding or late ovulation. Under nutrition and low BMI on the other hand might suppress hypothalamic functioning resulting in hypothalamic amenorrhea [4].

Another vital landmark in the reproductive development of the female is age at menarche, which refers to the period when a female is first menstruated. It is the end of pubertal development and the formation of the ability to procreate. In recent decades, there has been a secular shift in menarche age, with globally spreading evidence that advances in nutrition, socioeconomic status, and increasing prevalence of childhood obesity are the causes of this shift. Higher levels of adiposity have been associated with premature HPO axis activation that could be caused by leptin and insulin pathways. Hence, BMI does not only affect the period of menstruation, but it also has the possibility of affecting the time of menarche. The growing patterns in childhood obesity, early puberty and menarche, as well as the ethno-racial variations in the impact of BMI on reproductive features of the young females across the world, insist on unending review of these associations.

Menstrual features, such as the length of the cycle, length of flow, and levels of bleeding and other signs, e.g. dysmenorrhea, differ significantly across different individuals. Even though deviations within the physiological range are said to be normal, a constant deviation could be an indication of endocrine or metabolic imbalance. The polymenorrhea, oligomenorrhea, menorrhagia, hypomenorrhea, and dysmenorrhea can have a considerable impact on the quality of life, academic achievement, and psychological health. Although prevalence rates of menstrual problems are high, they have been underreported and overlooked especially among young women.

Medical students are a special population to observe the menstrual health. The rigorous schooling program, the competitive school climate, irregular working hours, sleeping difficulties, and the increased level of stress can precondition the malfunction of hypothalamo-pituitary-ovarian axis resulting in the occurrence of menstrual disorders. Stress that is chronic may induce changes in cortisol levels, which within a turn may influence the production of GnRH pulsatility and ovarian hormones. Moreover, other lifestyle considerations, including eating behavior, physical exercise activity, and changes in weight, are typical in college, and could also have an additional impact on BMI and menstruation [5].

Many medical conditions such as thyroid dysfunction, polycystic ovarian syndrome (PCOS), anemia and chronic systemic illnesses may lead to irregular or missed menses. A large number of these conditions can be diagnosed and treated early. Nevertheless, menstrual health is a neglected part of primary health care to young women. It is said that over 90 percent of menstrual issues can be prevented by early diagnosis and proper treatment. The etiological connection of menstrual disorders, BMI, and dietary habits can potentially be used in preventing early measures and specific interventions [6].

The relevance of finding the relationship between the body mass index and the age at which menarche occurs is especially significant, as early or late menarche has long-term health consequences. Early menarches have been implicated with higher risks of metabolic syndrome, cardiovascular disease, breast cancer and psychosocial difficulties, whereas slow menarche can be an indication of chronic undernutrition or endocrine defects. Considering the increasing cases of overweight and obesity in adolescents and young adults, the investigation of the effects of BMI and its effect on the onset of menarche and the future menstrual pattern is of a great public health interest.

It is on this basis that this cross-sectional study was carried out on the undergraduate female medical and paramedical students of a tertiary medical center. The objective of the study was to establish the mean age on menarche, patterns of menstrual cycles, the prevalence and the nature of menstrual disorders, and its relationship with family history, BMI, and dietary habits. The recognition of risk factors that can be altered, like abnormal BMI and unhealthy dietary habits, is the goal of this study in order to enrich the early prevention strategies and spread the information about reproductive health among the young females.

Methodology

Study Design: The present study was a hospital-based cross-sectional analytical study conducted to evaluate the association of Body Mass Index (BMI) with age at menarche and menstrual characteristics among young females. The design was chosen to assess the relationship between BMI and menstrual variables at a single point in time within the defined study population.

Study Area: The study was conducted in the Department of Obstetrics and Gynaecology at Nalanda Medical College and Hospital, Patna, Bihar, India.

Study Duration: The study was carried out over a period of six months from March 2025 to August 2025.

Sample Size: A total of 140 young females were included in the study. The sample size was determined based on feasibility within the study duration and the availability of eligible participants attending the department during the study period.

Study Population: The study population comprised young, unmarried females aged 17–25 years who attended the Department of Obstetrics and Gynaecology during the study period and met the eligibility criteria. Participants were selected consecutively until the required sample size was achieved.

Data Collection: Data were collected using a predesigned and structured questionnaire after obtaining informed consent from the participants. The questionnaire included demographic details such as age and socioeconomic status, dietary habits including daily calorie intake and junk food consumption, and a detailed menstrual history. Information regarding age at menarche (based on recall), cycle length, duration and regularity of menstruation, amount of bleeding (assessed by number of sanitary pads used per day), presence of clots, dysmenorrhoea, hypomenorrhoea, menorrhagia, oligomenorrhoea, polymenorrhoea, and premenstrual symptoms was recorded. Medical history, drug history, and family history of menstrual disorders were also documented. A thorough general physical examination was conducted with special attention to pallor, icterus, thyroid enlargement, and per abdominal findings.

Inclusion Criteria

- Unmarried females aged 17–25 years
- Those willing to participate and provide informed consent

Exclusion Criteria

- Married females
- Females on treatment for menstrual disorders
- History of primary amenorrhoea
- History of pelvic surgery
- Known endocrine disorders (e.g., thyroid disorders)

Study Procedure: Eligible participants attending the outpatient department were screened according to the inclusion and exclusion criteria. After obtaining informed consent, the structured questionnaire was administered. Anthropometric measurements were recorded using a standardized weighing machine for weight and a non-stretchable measuring tape for height. BMI was calculated using the formula weight in kilograms divided by the square of height in meters (kg/m²). Based on calculated BMI values, participants were categorized into standard BMI groups. Menstrual characteristics were classified according to predefined criteria, such as normal cycle length (21–35 days), polymenorrhoea (<21 days), oligomenorrhoea (>35 days), and normal duration of flow (2–7 days). The collected data were entered into Microsoft Excel and checked for completeness and accuracy before analysis.

Statistical Analysis: The collected data were analyzed using appropriate statistical software. Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to summarize demographic variables, BMI, age at menarche, and menstrual characteristics. Inferential statistical tests were applied to determine associations between variables. The Chi-square test was used to assess the association between BMI categories and menstrual abnormalities, while the independent sample t-test was used to compare the mean age at menarche across different BMI groups. A p-value of less than 0.05 was considered statistically significant."

Result

Table 1 presents the mean values of various demographic, dietary, menstrual, and anthropometric parameters among the 140 participants. The mean age was 21.62 ± 1.98 years. The average daily calorie intake was 2184.5 ± 242.36 kcal. The mean age at menarche was 13.21 ± 1.24 years. The average menstrual cycle duration was 4.36 ± 1.08 days, while the mean menstrual cycle length was 29.42 ± 4.62 days (n = 136). The mean estimated blood loss per cycle was 33.85 ± 10.92 ml. In terms of anthropometry, the mean height was 156.84 ± 5.44 cm, mean weight was 54.62 ± 8.74 kg, and the average BMI was 22.18 ± 3.12 kg/m². Overall, the study population demonstrated values largely within normal physiological ranges.

Table 1: T-Test showing mean value of different parameters (N = 140)

Parameters	N	Mean	Std. Deviation	Std. Error Mean
Age (Years)	140	21.62	1.98	0.17
Approximate Calories (kcal)	140	2184.5	242.36	20.48
Age of Menarche (Years)	140	13.21	1.24	0.1
Menstrual Cycle Duration (days)	140	4.36	1.08	0.09
Menstrual Cycle Length (Days)	136	29.42	4.62	0.39
Amount of Blood Loss (ml/cycle)	140	33.85	10.92	0.92
Height (cm)	140	156.84	5.44	0.46
Weight (Kg)	140	54.62	8.74	0.74
BMI (kg/m²)	140	22.18	3.12	0.26

Table 2 shows the distribution of BMI categories among the 140 participants. The majority had normal BMI (18.5–24.99), accounting for 86 individuals (61.4%). Underweight participants (<18.5) comprised 22 cases (15.7%), while 26 participants (18.6%) were overweight (25–29.99). Obesity (≥30) was observed in 6 participants (4.3%). Overall, most participants fell within the normal BMI range, with smaller proportions at the underweight and obese extremes.

Table 2: Distribution of BMI Categories (N = 140)		
BMI Group	**Frequency**	**Percentage**
Underweight (<18.5)	22	15.70%
Normal (18.5–24.99)	86	61.40%
Overweight (25–29.99)	26	18.60%
Obese (≥30)	6	4.30%
Total	**140**	**100%**

Table 3 demonstrates a statistically significant association between BMI group and menstrual cycle pattern ($p < 0.001$). Irregular cycles were most common among underweight girls, with 50.0% reporting irregular menstruation, followed by overweight (42.3%) and obese (33.3%) participants. In contrast, the majority of girls with normal BMI had regular cycles (90.7%), with only 9.3% reporting irregularity. Overall, 22.9% of participants had irregular cycles, and menstrual irregularity was more prevalent at the extremes of BMI, indicating a strong relationship between abnormal BMI and disturbed menstrual patterns.

Table 3: Correlation study of BMI & Menstrual cycle pattern (N = 140)				
BMI Group	**Regular**	**Irregular**	**Total**	**P-value**
Underweight	11 (50.0%)	11 (50.0%)	22	<0.001
Normal	78 (90.7%)	8 (9.3%)	86	
Overweight	15 (57.7%)	11 (42.3%)	26	
Obese	4 (66.7%)	2 (33.3%)	6	
Total	108 (77.1%)	32 (22.9%)	140	

Table 4 shows a statistically significant association between BMI category and age at menarche ($p = 0.002$). The mean age at menarche was highest among underweight girls (13.78 ± 1.18 years), followed by those with normal BMI (13.25 ± 1.21 years), while overweight (12.86 ± 1.09 years) and obese girls (12.64 ± 1.02 years) experienced menarche at a younger age. These findings indicate an inverse relationship between BMI and age at menarche, with higher BMI associated with earlier onset of menarche.

Table 4: Association between BMI Category and Age at Menarche (Independent Sample t-test)				
BMI Category	**N**	**Mean Age at Menarche (Years)**	**Std. Deviation**	**P-value**
Underweight	22	13.78	1.18	0.002
Normal	86	13.25	1.21	
Overweight	26	12.86	1.09	
Obese	6	12.64	1.02	

Discussion

The current research findings indicated that there existed a strong relationship between Body Mass Index (BMI) and age at menarche on one side, and menstruation traits on the other side, among young females. Participants had a mean BMI of 22.18 ± 3.12 kg/m 2, and most of them (61.40) were within the normal BMI range. The statistical test results indicated that there was a statistically significant relationship between the BMI category and regularity of menstrual cycles ($p = 0.001$) and between BMI and age at menarche ($p = 0.002$). The participants who had a higher BMI had earlier menarches (12.64 ± 1.02 years in the obese and 12.86 ± 1.09 years in the overweight participants) than the participants with normal BMI (13.25 ± 1.21 years) and those who were underweight (13.78 ± 1.18 years). The results are correlated with the accumulating literature that any abnormal BMI, both low and high, has a negative impact on reproductive health".

The same results were presented by Thapa and Shrestha (2015) [7] who hold research among 253 adolescent females and found out that almost half of them had abnormal BMI. They statistically found that there was significant association between BMI and irregular menstrual cycle ($p=0.024$), oligomenorrhea ($p=0.027$), polymenorrhea ($p=0.006$), and hypomenorrhea ($p= 0.01$). Comparatively, our analysis showed that BMI is even strongly related with menstrual irregularity ($p < 0.001$), which

supports the idea that under- or over nutrition disrupts hypothalamic pituitary ovary axis. Although Thapa and Shrestha (2015) [7] emphasized more on dysmenorrhea as the most frequent complaint, our study paid more attention to the cycle regularity and age at menarche, which expanded the knowledge on BMI-related menstrual changes.

The effect of BMI on the length and the duration of menstrual cycle in men observed in our study is in line with the results of the study carried out by Osayande et al. (2014) [8] who reported that the increased BMI was positively correlated with longer length of menstrual cycle ($r = 0.52$, 95% CI = 0.280.69, $p < 0.0001$) and longer duration of menses ($r = 0.38$, 95% CI = The average menstrual cycle and mean duration of flow was 29.42 /4.62 days and 4.36/1.08 days respectively in our study. Though most of the participants had cycle within the normal range, overweight and obese individuals reported greater proportions of abnormal cycles (42.3% and 33.3%, respectively) than the normal BMI (9.3%). This is a similarity which implies that high levels of adiposity can be acting in the same direction as excess estrogen through peripheral aromatization and create imbalances in the cycle. Nevertheless, in contrast to Osayande et al. (2014) [8], who reported the direct positive correlation between BMI and the duration of a cycle, we found that irregularity, but not absolute increase tended to be more observable in higher BMI groups.

According to Tanveer Alam et al. (2013) [3], menstrual cycle length and menses duration were significantly long among overweight and obese students than control and underweight students in their first-year MBBS students between 18 and 25 years. Their data is consistent in part with ours due to the fact that overweight and obese participants of our research also exhibited increased occurrence of irregular cycles. Nevertheless, we did not find significant increase in the mean cycle length in the whole cohort, which might be explained by disparities in sample size ($n = 140$ in our study and $n = 50$ in their study) and population features. However, the two studies put stress on the fact that excess body weight is a factor that causes menstrual disturbances in what seemingly young females have been considered healthy.

On the same note, Lakkawar et al. (2014) [9] established that and higher BMI and junk food intake were linked with elevated rates of irregular menstruation among 200 female medical students in Pondicherry, India. This confirms our finding that both abnormal BMI groups (underweight) and overweight (42.3% irregular cycles) BMI groups had significantly high rates of menstrual irregularity than the normal BMI group (9.3%). These similar observations in the various geographical locations underscore the possibility of the lifestyle variables that cause such changes in BMI to have a universal role in causing menstrual dysfunction.

According to Hemant et al. (2013) [10], the correlation between BMI of high-weight and irregular menstruation was significantly high (49.826, $p < 0.001$) and 90.4% of the girls with high BMI had irregular menstrual cycles. Even though the percentage of irregular cycles among our study participants (obese) was smaller than the one noted by Hemant et al (33.3), the correlation was still statistically significant ($p < 0.001$). The statistical divergence could be explained by fluctuations in the distribution of BMI since only 4.30% of our participants were obese, whereas this ratio could be higher in their cohort. However, the two studies establish that high BMI is a major disturbance of menstrual rhythm.

On age at menarche, our result of negative correlation of BMI with menarcheal age ($p = 0.002$) is highly consistent with Osayande et al. (2014) [8], who also found that heavier BMI was linked with earlier menarche. This association is biologically plausible as a higher level of leptin and estrogen in people with a greater degree of adiposity could initiate premature hypothalamic-pituitary-gonadal axis. On the other hand, individuals with low body fat in our research recorded the highest mean age at menarche (13.78 ± 1.18 years) and this endorses the idea that insufficient body fat postpones pubertal development. This is in line with previous results of adolescent populations in India and Nigeria where it has been found that reproductive maturation was affected by nutritional status (Umeora and Egwuatu, 2008; Verma et al., 2011) [11,12].

On the whole, our results are in line with the existing literature that shows that both low and high BMI are closely related to menstrual irregularities and change in menarche timing. Nonetheless, in comparison to some of the preceding studies, our study gives quantitative values in detail of cycle length (29.42 ± 4.62 days), flow duration (4.36 ± 1.08 days), and blood loss (33.85 ± 10.92 ml), which gives the menstrual profile in greater details, with respect to the BMI categories. The statistically significant relationships have been observed ($p < 0.001$ with menstrual regularity and $p = 0.002$ with menarcheal age) justifying the need to identify a deviation of BMI in young female at a young age. Preventive strategies focusing on maintaining optimal BMI through balanced diet and physical activity may help reduce future risks of anovulation, infertility, metabolic syndrome, and other chronic conditions associated with menstrual dysfunction.

Conclusion

The present study concludes that body mass index (BMI) has a significant association with both age at menarche and menstrual characteristics among young females. A clear trend was observed wherein higher BMI was linked with an earlier onset of

menarche, while lower BMI was associated with comparatively delayed menarche. Furthermore, menstrual irregularities were more prevalent among participants at the extremes of BMI, particularly in underweight and overweight groups, whereas those with normal BMI predominantly exhibited regular menstrual cycles. These findings highlight the influence of nutritional status and body composition on reproductive health and emphasize the importance of maintaining a healthy BMI to promote optimal menstrual function in young females.

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