

Association Of Anthropometric Indices With Menstrual Abnormalities In Adolescent Girls: A Cross-Sectional Study

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Abstract

Background: Excess adiposity and altered fat distribution can disrupt the hypothalamic–pituitary–ovarian axis, leading to menstrual abnormalities during adolescence. Evidence directly comparing different anthropometric indices as predictors of menstrual disturbances remains limited.

Objectives: To evaluate the association of body mass index (BMI), waist–hip ratio (WHR), and waist–height ratio (WHtR) with menstrual abnormalities among adolescent girls and to identify the most reliable anthropometric predictor.

Methods: A hospital-based cross-sectional study was conducted among 150 adolescent girls aged 16–24 years attending a tertiary care hospital in Chennai, India. Anthropometric measurements were obtained using standardized procedures, and menstrual characteristics were assessed using a pretested structured questionnaire. Associations were examined using chi-square tests and multivariable logistic regression analysis. Receiver operating characteristic (ROC) curves were used to assess the predictive performance of anthropometric indices.

Results: The overall prevalence of menstrual abnormalities was 42.0%. Menstrual abnormalities were significantly more common among overweight and obese participants compared with those having normal BMI ($p < 0.001$). After adjustment for age and age at menarche, WHtR ≥ 0.5 emerged as the strongest independent predictor of menstrual abnormalities (adjusted OR 3.12; 95% CI: 1.65–5.91), followed by overweight/obese BMI (adjusted OR 2.41; 95% CI: 1.28–4.56) and high WHR (adjusted OR 1.89; 95% CI: 1.01–3.54). WHtR demonstrated the highest discriminatory ability (AUC 0.71; 95% CI: 0.63–0.79).

Conclusion: Anthropometric indices are significantly associated with menstrual abnormalities in adolescents. Waist–height ratio appears to be the most effective screening tool and may facilitate early identification of adolescents at risk for menstrual disturbances.

Keywords: Anthropometric indices; Body mass index; Waist–height ratio; Menstrual abnormalities; Adolescents

How To Cite This Article: Sparsha J, Logeswari BM, Revathy TG. Association of anthropometric indices with menstrual abnormalities in adolescent girls: a cross-sectional study. *Int J Drug Deliv Technol.* 2026;16(9s): 537-541; Doi: 10.25258/Ijddt.16.9s.53

Introduction

Adolescence represents a critical period of physical growth, neuroendocrine maturation, and establishment of regular reproductive function. The menstrual cycle is regulated by a complex interaction between the hypothalamus, pituitary gland, ovaries, and peripheral tissues, and disturbances in this axis can result in

menstrual abnormalities [1,2]. Menstrual disorders such as irregular cycles, altered duration, and abnormal flow are commonly reported among adolescent girls and may adversely affect physical well-being, psychological health, and quality of life [3,4]. Importantly, menstrual disturbances during adolescence may serve as early indicators of future reproductive and metabolic disorders.

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In recent decades, the prevalence of overweight and obesity has increased substantially across all age groups, including adolescents. According to the World Health Organization, obesity is a major public health concern associated with multiple metabolic and endocrine complications [5]. Excess adiposity influences female reproductive physiology through mechanisms such as insulin resistance, hyperinsulinemia, altered gonadotropin secretion, and increased peripheral estrogen production, all of which may interfere with ovulation and menstrual regularity [6,7].

Anthropometric indices are simple, noninvasive tools used to assess body composition and fat distribution. Body mass index (BMI) is widely used to define overall adiposity; however, it does not adequately reflect central fat accumulation or body fat distribution [8]. Measures of central obesity, such as waist circumference, waist-hip ratio (WHR), and waist-height ratio (WHtR), have been shown to correlate more closely with cardiometabolic and endocrine risk than BMI alone [9].

Several studies have reported an association between obesity and menstrual abnormalities. Population-based studies have demonstrated that increased body weight and central adiposity are significantly associated with menstrual cycle irregularity among adolescents and young women [10,11]. However, there is limited consensus regarding which anthropometric index best predicts menstrual abnormalities in adolescents, as many studies have evaluated single indices in isolation. The present study was therefore undertaken to evaluate the association of BMI, WHR, and WHtR with menstrual abnormalities among adolescent girls and to identify the most reliable anthropometric predictor.

Materials and Methods

Study Design and Setting

A hospital-based cross-sectional study was conducted over a period of six months in the Department of Obstetrics and Gynaecology at Sree Balaji Medical College and Hospital, Chennai, Tamil Nadu, India.

Study Population and Sample Size

A total of 150 adolescent girls aged 16–24 years were recruited using consecutive sampling. Participants who provided informed consent were included in the study.

Inclusion criteria: Adolescent girls aged 16–24 years who consented to participate.

Exclusion criteria: Pregnant participants, those using hormonal contraceptives, individuals with known

endocrine or organic diseases, and those unwilling to participate.

Data Collection and Measurements

Data were collected using a pretested semistructured questionnaire that included information on sociodemographic characteristics, age at menarche, menstrual cycle length, duration of menstrual bleeding, and presence of menstrual abnormalities. Menstrual abnormality was defined as the presence of oligomenorrhea, polymenorrhea, amenorrhea, or dysmenorrhea.

Anthropometric measurements including height, weight, waist circumference, and hip circumference were obtained by trained investigators following World Health Organization guidelines. Body mass index was calculated as weight (kg) divided by height squared (m^2) and classified using standard WHO criteria. Waist-hip ratio and waist-height ratio were calculated using standard formulas and categorized according to established cutoffs.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 22. Continuous variables were expressed as mean \pm standard deviation, and categorical variables as frequencies and percentages. Associations between anthropometric indices and menstrual abnormalities were assessed using chi-square tests. Multivariable logistic regression analysis was performed to identify independent predictors after adjusting for age and age at menarche. Receiver operating characteristic (ROC) curve analysis was used to compare the predictive accuracy of BMI, WHR, and WHtR. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of Sree Balaji Medical College and Hospital. Written informed consent was obtained from all participants prior to data collection.

Results

A total of 150 adolescent girls were included in the final analysis. The mean age of the participants was 19.8 ± 2.3 years, with ages ranging from late adolescence to early adulthood. The mean age at menarche was 12.6 ± 1.1 years, indicating timely pubertal onset in the majority of participants. The mean body mass index (BMI) of the study population was 23.6 ± 4.8 kg/m^2 , reflecting a mixed distribution of normal weight, overweight, and obese

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individuals. Overall, 63 participants (42.0%) reported at least one form of menstrual abnormality. Among these, irregular menstrual cycles constituted the most commonly reported disturbance, followed by altered duration and dysmenorrhea. This finding indicates a substantial burden of menstrual health problems within the study population. Baseline demographic and anthropometric characteristics of the participants are summarized in Table 1. The mean waist circumference and hip circumference were 78.2 ± 9.4 cm and 94.6 ± 8.1 cm, respectively. The mean waist-hip ratio (WHR) was 0.83 ± 0.07 , while the mean waist-height ratio (WHtR) was 0.49 ± 0.06 , values that approach commonly used thresholds for central obesity.

Table 1. Baseline characteristics of study participants (n = 150)

Variable	Mean \pm SD / n (%)
Age (years)	19.8 \pm 2.3
Age at menarche (years)	12.6 \pm 1.1
Height (cm)	158.4 \pm 6.5
Weight (kg)	59.1 \pm 11.2
Body mass index (kg/m ²)	23.6 \pm 4.8
Waist circumference (cm)	78.2 \pm 9.4
Hip circumference (cm)	94.6 \pm 8.1
Waist-hip ratio	0.83 \pm 0.07
Waist-height ratio	0.49 \pm 0.06

The distribution of anthropometric indices is presented in Table 2. Based on BMI classification, 44.7% of participants had normal BMI, while 28.0% were overweight and 15.3% were obese. A high WHR was observed in 36.0% of participants, whereas nearly half of the study population (48.0%) had a WHtR ≥ 0.5 , suggesting a high prevalence of central adiposity even among individuals who were not obese by BMI criteria.

Table 2. Distribution of anthropometric indices among participants

Anthropometric category	n (%)
BMI category	
Underweight (<18.5 kg/m ²)	18 (12.0)
Normal (18.5–24.9 kg/m ²)	67 (44.7)
Overweight (25.0–29.9 kg/m ²)	42 (28.0)
Obese (≥ 30 kg/m ²)	23 (15.3)
Waist-hip ratio	
Normal	96 (64.0)
High	54 (36.0)
Waist-height ratio	

<0.5	78 (52.0)
≥ 0.5	72 (48.0)

Associations between anthropometric indices and menstrual abnormalities are detailed in Table 3. The prevalence of menstrual abnormalities increased progressively with increasing BMI category. While only 28.4% of participants with normal BMI reported menstrual abnormalities, the proportion increased to 59.5% among overweight and 56.5% among obese participants, and this association was statistically significant ($p < 0.001$). Similarly, menstrual abnormalities were significantly more common among participants with a high WHR compared with those having a normal WHR (57.4% vs. 33.3%; $p = 0.002$).

Table 3. Association between anthropometric indices and menstrual abnormalities

Anthropometric index	Normal menstruation n (%)	Menstrual abnormality n (%)	p value
BMI category			<0.001
Underweight	12 (66.7)	6 (33.3)	1
Normal	48 (71.6)	19 (28.4)	
Overweight	17 (40.5)	25 (59.5)	
Obese	10 (43.5)	13 (56.5)	
Waist-hip ratio			0.002
Normal	64 (66.7)	32 (33.3)	1
High	23 (42.6)	31 (57.4)	
Waist-height ratio			
<0.5	57 (73.1)	21 (26.9)	1
≥ 0.5	30 (41.3)	42 (58.7)	

A particularly strong association was observed with WHtR. Participants with WHtR ≥ 0.5 had more than double the prevalence of menstrual abnormalities compared with those having WHtR <0.5 (58.7% vs. 26.9%), and this difference was highly statistically significant ($p < 0.001$). This finding underscores the potential relevance of central fat distribution in relation to menstrual health.

Multivariable logistic regression analysis was performed to identify independent predictors of menstrual abnormalities after adjusting for potential confounders. As shown in Table 4, WHtR ≥ 0.5 emerged as the strongest independent predictor of menstrual abnormalities (adjusted OR 3.12; 95% CI: 1.65–5.91; $p <$

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0.001). Overweight or obese BMI status was also independently associated with menstrual abnormalities (adjusted OR 2.41; 95% CI: 1.28–4.56; $p = 0.006$), while a high WHR showed a weaker but statistically significant association (adjusted OR 1.89; 95% CI: 1.01–3.54; $p = 0.041$).

Table 4. Multivariable logistic regression analysis for predictors of menstrual abnormalities

Predictor	Adjusted OR	95% CI	p value
Overweight/obese BMI	2.41	1.28–4.56	0.006
High WHR	1.89	1.01–3.54	0.041
WHtR ≥ 0.5	3.12	1.65–5.91	<0.001

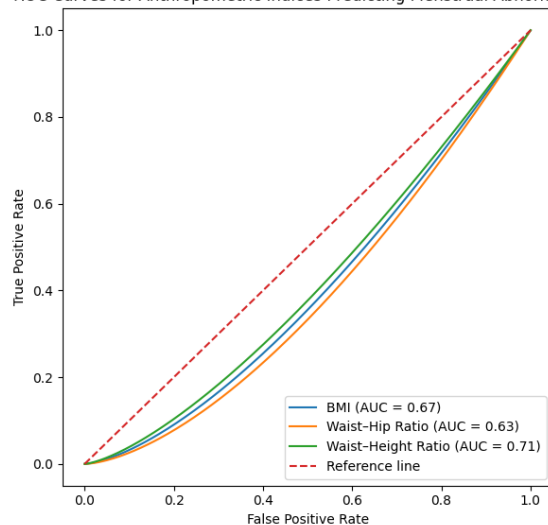
Receiver operating characteristic (ROC) curve analysis was conducted to compare the predictive performance of different anthropometric indices. (Table-6)

Table 6. Predictive accuracy of anthropometric indices for menstrual abnormalities

Anthropometric index	AUC	95% CI
BMI	0.67	0.58–0.75
Waist–hip ratio	0.63	0.55–0.71
Waist–height ratio	0.71	0.63–0.79

WHtR demonstrated the highest discriminatory ability for identifying menstrual abnormalities, with an area under the curve (AUC) of 0.71 (95% CI: 0.63–0.79). In comparison,

ROC Curves for Anthropometric Indices Predicting Menstrual Abnormalities



BMI showed a moderate predictive ability (AUC 0.67), while WHR exhibited the lowest discrimination (AUC 0.63). (Fig-1) These findings indicate that WHtR may be a more effective screening measure for menstrual abnormalities than BMI or WHR in adolescent girls. (Fig-1)

Discussion

The present study demonstrates a significant association between anthropometric indices and menstrual abnormalities among adolescent girls, with an overall prevalence of menstrual disturbances of 42.0%. This prevalence is comparable to previous epidemiological studies reporting menstrual disorder rates ranging from 30% to 50% among adolescents [3,4]. Menstrual abnormalities were significantly more prevalent among overweight and obese participants, supporting existing evidence that excess adiposity adversely affects menstrual regularity. Similar findings have been reported by Bae et al., who observed a strong association between increased BMI and menstrual cycle irregularity among Korean adolescents [10]. Naz et al. also documented a high prevalence of menstrual disorders among adolescents with higher body weight, indicating obesity as a modifiable risk factor [4]. Beyond overall adiposity, the present study identified measures of central obesity as stronger predictors of menstrual abnormalities than BMI. Participants with elevated waist–hip ratio and waist–height ratio had significantly higher odds of menstrual disturbances. This observation is consistent with prior studies demonstrating that central fat accumulation is more closely associated with insulin resistance and endocrine dysfunction than generalized obesity [6,12]. Waist–height ratio emerged as the most robust independent predictor in the present study and demonstrated the highest discriminatory ability on ROC analysis. Similar results were reported by Amgain et al., who found WHtR to be superior to BMI and WHR in predicting menstrual abnormalities among nursing students [11]. Ashwell and Gibson also emphasized that WHtR is a simple and reliable screening tool that correlates strongly with metabolic and reproductive risk across different populations [13]. The biological plausibility of this association may be explained by the close relationship between central adiposity, visceral fat accumulation, and insulin resistance. Increased insulin levels can stimulate ovarian androgen production and suppress hepatic sex hormone–binding globulin synthesis, leading to hormonal imbalance and ovulatory

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dysfunction [14]. These mechanisms underscore the relevance of central obesity assessment in adolescent reproductive health. From a clinical and public health perspective, the findings of this study suggest that dependance on BMI alone may be the risk of menstrual abnormalities in adolescents with normal weight but increased central adiposity. Incorporation of WHtR into routine adolescent health screening may facilitate early identification of at-risk individuals and enable timely lifestyle interventions aimed at improving both metabolic and reproductive outcomes.

Strengths and Limitations

The strengths of this study include the use of multiple anthropometric indices, standardized measurement techniques, and application of multivariable analysis to identify independent predictors. However, the cross-sectional design limits causal inference, and the hospital-based sample may restrict generalizability to the broader adolescent population. Hormonal and biochemical parameters were not assessed, which could have provided further insight into underlying mechanisms.

Conclusion

Anthropometric indices are significantly associated with menstrual abnormalities in adolescent girls. Waist–height ratio showed as the most reliable predictor and may be recommended as a simple screening tool for early identification and prevention of menstrual and reproductive health problems in adolescents.

Conflict of interest: Nil

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