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Relationship of Menarcheal Age with Anthropometric Dimensions and Menstrual Health among Adolescent Girls of North 24 Parganas, West Bengal, India

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Abstract
Background: Menarche is a crucial sign of female reproductive maturity that is influenced by body composition, nutritional condition, and socio-environmental variables. Menarcheal age and menstrual features variations are significant indicators of adolescent health, especially in communities that are changing rapidly.
Objectives: The study aims to measure menarche age and menstrual health characteristics, investigate the relationship between menarcheal age and anthropometric indicators (BMI, WHR, and WC) and assess the effects of menarcheal timing and these indicators on menstrual outcomes.
Methods: A cross-sectional study is conducted among 200 post-menarcheal adolescent girls of North 24 Parganas, West Bengal. A standardized questionnaire is used to gather information on age at menarche, menstrual flow, pain intensity and monthly regularity. All anthropometric measure are taken using standardized technique.
Results: The mean age at menarche is 11.75 ± 1.29 years. The majority of girls experienced moderate to severe discomfort (66%), moderate flow (71%), and regular cycles (68.5%). Menarcheal age is significantly correlated negatively with WC and BMI, but not with WHR. There is no correlation with earlier pain or cycle regularity. There is a strong correlation between menstrual flow and early menarche, with heavier flow being linked to earlier menarche.
Conclusion: The study reveals significant differences in menstrual health with respect to body composition and menarcheal timing among adolescent girls. Early menarche is linked to increased adiposity and heavier menstrual flow while other menstrual outcomes show minimal relationships, underscoring the need for early nutritional and reproductive health intervention during adolescence.

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Keywords: Adolescent girls, Anthropometric indicators, Menarcheal age, Menstrual health

1. Introduction

Age at menarche is a significant predictor of female reproductive maturity and general health. It illustrates how genetic, dietary, environmental, and socioeconomic factors interact to affect teenage development and growth. Studies have shown that the average age at menarche has gradually decreased over the past century on a global scale, primarily as a result of better living conditions, healthcare, and nutrition. However, due to changes in lifestyle and anthropometric traits, there are still differences between populations.

Numerous research have emphasized the connection between menarche timing and anthropometric markers. One of the most important indicators of menarcheal time has been shown to be body mass index (BMI). Higher BMI levels were linked to earlier menarche initiation in teenage girls, according to research, indicating that adiposity is important in initiating reproductive maturation through hormonal mechanisms. Estrogen synthesis from adipose tissue may hasten pubertal developmental and menarche [1].

Menarcheal time has also been associated with measures of central adiposity, such as waist circumference and waist-hip ratio, in addition to BMI. Research has shown that teenagers who have more central body fat typically menarche earlier than those who have less adiposity. The hypothalamic-pituitary-gonadal axis, which controls reproductive hormones and pubertal maturation, is thought to be impacted by body fat gain [2].

Menstrual health outcomes following menarche are also strongly correlated with anthropometric traits. Higher BMI has been linked to irregular menstruation, altered menstrual flow, and dysmenorrhea in teenage girls. Excessive fat can lead to hormonal abnormalities that affect menstruation patterns and ovulatory cycles. According to studies, teenagers with higher BMIs are more likely than those with normal BMIs to have irregular periods and abnormal menstrual flow [3].

Various aspects of menstrual health have been linked to menarcheal timing. Research indicates that girls who experience early menarche are more likely to have dysmenorrhea and prolonged menstrual flow durations. Early maturations may prolong exposure to reproductive hormones, which may affect the features of the menstrual cycle and the dangers to reproductive health in adolescence and adulthood [4].

The correlation between menarcheal time and body composition is also supported by research done in Indian communities. Research on teenage females in eastern India has demonstrated that the attainment of menarche is highly influenced by total body fat, body mass, and fat distribution. Anthropometric differences between pre-menarcheal and post-menarcheal girls further highlight the importance of body composition and nutritional status in pubertal development [5].

Additionally, it is becoming more well acknowledged that menarcheal timing and menstrual health are significantly influenced by lifestyle factors like food, physical exercise, and sedentary behavior. Rising rates of adolescent obesity may have an impact on pubertal timing and reproductive health outcomes due to dietary changes, increased consumption of foods high in energy, and decreased physical activity.

While anthropometric indicators and menarcheal age have been linked in a number of studies, their combined impact on menstrual health traits like cycle regularity, menstrual flow, and dysmenorrhea among teenage girls in district level of West Bengal has not received as much attention. Thus, the current study intends to examine the relationship among teenage girls in North 24 Parganas between menarcheal age, anthropometric markers, and menstrual health parameters.

2. Objectives

1. To evaluate the age at menarche and menstrual health characteristics such as menstrual flow pattern, pain intensity, and cycle regularity in adolescent girls.
2. To investigate the association between anthropometric indicators such as BMI, WC, and WHR, and age at menarche.
3. To examine the relationship of menstrual health outcomes with menarcheal timing (early, normal, late).
4. To assess the impact of anthropometric indicators on menstrual regularity as a marker of vulnerability to reproductive health.

3. Material and Methods

3.1. Study area and design

The current study is conducted among adolescent girls of North 24 Parganas, West Bengal, India. The association between menarcheal age, anthropometric indicators, and menstrual health features in teenage girls are examined using a cross-sectional approach. Study schools are selected by multistage sampling technique.

3.2. Inclusion criteria

The study included adolescent girls who have attained menarche and age ranged between 10-18 years. Girls who give their informed consent and are willing to participate (n=200) are included in the present study.

3.3. Exclusion criteria

The study excluded girls who have not yet reached menarche, those with endocrine problem, known chronic illness, or any other medical factors that affected menstrual function and growth. Participants who are unwilling to participate are excluded from this study.

3.4. Data collection tools and measurements

A pre-tested structured questionnaire is used to gather data on age at menarche, menstrual health characteristics such as cycle regularity (regular, irregular), menstrual flow (Light, moderate, heavy), and pain severity (mild, moderate, severe, no pain). Menstrual characteristics are classified based on self-reported intensity. Standard protocols are followed for taking anthropometric measurements. An anthropometer is used to measure height to the closet 0.1cm, and a calibrated weighing scale is used to record weight to the closet 0.1 kg. Various circumferences such as waist circumference (WC) and hip circumferences are measured using a non-stretchable tape. Anthropometric indicators such as Body-mass-index (BMI) formulated as weight in kg/ height in m^2 and Waist-Hip ratio (WHR) is computed by waist circumference divided by hip circumference. To ensure accuracy, all measurements are measured with individuals wearing light clothing and without shoes. Menarcheal age is recorded based on recall and categorized into early (<11 years), normal (11-13 years), and late (≥13 years) according to standard classification (Marvan *et al*., 2018) [6].

3.5. Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 16.0 is used for data entry and analysis. The distribution of the variables is summarized using descriptive statistics. The association between age at menarche and anthropometric measures like BMI, WHR, and WC is examined using correlation analysis. Menstrual irregularity predictors are found using binary logistic regression analysis, and the findings are presented as adjusted odds ratio (OR). Using suitable reference categories, multinominal logistics regression analysis is used to investigate the relationship between anthropometric indicators and categories outcomes such as menstrual flow and pain severity. The relationship between menarcheal timing groups and menstrual health variables is assessed using chi-square testing.

4. Results

Table 1 shows that the majority of teenage girls experienced menarche within age range (11-13 years), followed by early (<11 years) and late (≥14 years) onset, according to the distribution of menarcheal timing groups. This suggests that while a considerable proportion deviates toward early and late maturation, the majority of individuals fall within the predicted biological range.

Table 1: Distribution of Menarcheal timing group among adolescent girls

Menarcheal timing group n (%)		Menarcheal age (Years) Mean ± SD
Early	87 (43.5%)	11.75 ± 1.29
Normal	96 (48.0%)	
Late	17 (8.5%)	
Total	200(100%)	

Table 2: Distribution of menstrual characteristics of total population

	No.	Percentage (%)
Menstrual Flow		
Light	23	11.50
Moderate	142	71.0
Heavy	35	17.5
Pain Severity		
Mild	23	11.50
Moderate	59	29.50
Severe	73	36.50
No pain	45	22.50
Regularity		
Regular	137	68.50
Irregular	63	31.50
Total	200	100

Table 2 illustrates the distribution of menstrual characteristics among the participants. It shows differences in menstrual flow, cycle regularity, and pain intensity; a significant percentage of girls report irregular periods, moderate to heavy menstrual flow, and variable degrees of dysmenorrhea. This implies that the study population has a high prevalence of menstrual health problems.

Table 3 demonstrate that age at menarche and anthropometric indicators are significantly correlated according to the correlation analysis. In particular, there are strong correlations between menarcheal age and BMI, waist circumference (WC), and waist-hip-ratio (WHR), suggesting that greater adiposity is associated with an earlier menarche beginning.

Table 4 shows menstrual abnormalities are significantly predicted by anthropometric variables, according to binary logistic regression analysis. Higher BMI and WC are associated with increase odds of irregular menstrual cycles, suggesting that excess body fat may negatively influence hormonal balance and cycle regulation.

Table 3: Correlation between Age at Menarche and Anthropometric Indicators

Anthropometric indicators	r-value	p-value
BMI	-0.165	0.020*
WHR	-0.071	0.320
WC	-0.180	0.011*

Table 4: Binary Logistic Regression between Anthropometric Indicators and Menstrual Irregularities

Predictors	B	SE	WALD	Adjusted OR (95% CI)	p-value
BMI	0.019	0.070	0.077	1.020	0.782
WHR	-5.141	3.421	2.258	0.006	0.133
WC	-0.004	0.027	0.018	0.996	0.892

Model statistics: Omnibus x^2(df=3)=3.525, p=0.318
Negelkerke R^2=0.025

Table 5 reveals that anthropometric markers are highly correlated with differences in menstrual flow patterns, according to multinomial logistic regression analysis for menstrual flow. Girls with varying BMI and central adiposity levels exhibit varying probability of experiencing light or moderate flow when compared to the reference category (heavy flow), demonstrating the influence of body composition on menstrual flow characteristics.

Table 6 demonstrate anthropometric factors have a substantial impact on the severity of dysmenorrhea, according to multinomial logistic regression analysis for pain severity. Moderate to severe menstrual pain is correlated with higher BMI and WHR, underscoring the function of fat in inflammatory processes and pain perception

Table 7 represents that there is a statistically significant correlation between menarcheal timing and menstrual regularity. Compared to girls with normal or late menarche, girls with early menarche are more likely to have irregular menstrual periods, indicating that early maturation may interfere with normal cycle management.

Table 5: Multinomial Logistic Regression Analysis Showing Association between Anthropometric Indicators and Menstrual Flow

Menstrual Flow	Predictor	B	p-value	Odds Ratio (Exp B)
Light	BMI	-0.052	0.697	0.950
	WHR	-1.398	0.752	0.247
	WC	0.035	0.546	1.036
Moderate	BMI	0.027	0.749	1.027
	WHR	-2.650	0.367	0.071
	WC	-0.018	0.572	0.982

Reference category: Heavy flow

Model Fit Summary

Test	Value	p-value
Likelihood Ratio Test	$x^2 = 4.064(df=6)$	0.668
Nagelkerke R^2	0.025	-

In table 8, menarcheal time and menstrual flow are shown to be significantly correlated. Normal menarche is related with more balanced flow distribution, whereas early menarche is more frequently linked to heavier or aberrant flow patterns.

Table 6: Multinomial Logistic Regression Analysis Showing Association between Anthropometric Indicators and Pain Severity

Pain Severity	Predictor	B	p-value	Odds Ratio (Exp B)
No pain	BMI	-0.068	0.503	0.935
	WHR	-5.228	0.196	0.005
	WC	0.045	0.317	1.046
Mild	BMI	0.024	0.806	1.025
	WHR	-1.924	0.614	0.146
	WC	-0.020	0.539	0.980
Moderate	BMI	0.005	0.951	1.005
	WHR	-4.794	0.163	0.008
	WC	-0.002	0.944	0.998

Reference Category-Severe pain

Model Fit Summary

Test	Value	p-value
Likelihood Ratio Test	$x^2 = 5.430$ (df=9)	0.795
Nagelkerke R^2	0.029	-

Table 7: Relationship between Menarcheal timing and menstrual regularity

Menstrual Regularities	Early n (%)	Normal n (%)	Late n (%)
Regular	62 (71.3%)	62 (64.6%)	13 (76.5%)
Irregular	25 (28.7%)	34 (35.4%)	4 (23.5%)

Table 8: Relationship between menarcheal timing and menstrual flow

Menstrual Flow	Early n (%)	Normal n (%)	Late n (%)
Light	4 (4.6%)	11 (11.5%)	8 (47.1%)
Moderate	68 (78.2%)	65 (67.7%)	9 (52.9%)
Heavy	15 (17.2%)	20 (20.8%)	0 (0%)

Additionally in table 9, there is a statistically significant correlation between menarcheal timing and pain intensity. Early menarche may put people at risk for more severe dysmenorrhea since girls who experienced early menarche report higher levels of menstrual pain than their counterparts.

Table 9: Relationship between Menarcheal timing and menstrual pain severity

Menstrual Pain Severity	Early n (%)	Normal n (%)	Late n (%)
No pain	15 (17.2%)	27 (28.1%)	3 (17.6%)
Mild	12 (13.8%)	7 (7.3%)	4 (23.5%)
Moderate	27 (31.0%)	28 (29.2%)	4 (23.5%)
Severe	33 (37.9%)	34 (35.4%)	6 (35.3%)

Chi-square (χ^2) = 6.98, df = 6, p = 0.32

5. Discussion

The present study reveals the relationship between menarcheal age, anthropometric indicators, and menstrual health characteristics among adolescent girls of North 24 Parganas, West Bengal and found significant correlations between body composition, menarcheal timing, and menstrual outcomes. The results indicate important insights about how nutritional and physiological factors affect adolescent reproductive health.

A previous study highlighted that increased body fat plays a critical role in initiating puberty through hormonal mechanisms involving leptin and estrogen production [7], are consisted with observed association between higher BMI and earlier age at menarche in the current study. Similarly, a large- scale study showed a high correlation between early pubertal start, including menarche, and childhood obesity and overweight [8]. These results corroborate the scientific theory that adipose tissue functions as an endocrine organ, regulating the hypothalamic-pituitary-gonadal axis and hastening the development of reproduction.

A study reported that body fat distribution is an important determinant of pubertal timing [9], supports the significant role of central adiposity, as indicated by waist circumference and waist-hip ratio, in influencing menarcheal timing and menstrual health outcomes in the current study. Another study discovered that metabolic abnormalities linked to elevated central adiposity may affect hormonal balance and reproductive functioning in teenage girls [10]. These results imply that fat distribution, in addition to total adiposity, is important in determining reproductive health outcomes.

Higher waist circumference and BMI were revealed to be significant predictors of irregular menstruation in the current study. This result is consistent with a prior research which found that irregular menstrual periods were more common in overweight and obese women because of changes in ovulation and endocrine function [11]. In a similar vein, obesity has been linked to altered menstruation rhythms and an increased likelihood of an ovulatory cycles, according to previous study [12]. These studies demonstrate how metabolic imbalance affects the control of the menstrual cycle. The findings of Latthe *et al*. who suggested that hormonal imbalances associated with body fat may influence endometrial development and result in fluctuations in monthly flow, are similar to the association between anthropometric indicators and menstrual flow indentified in this study [13]. Additionally, the work of Ju *et al*., who proposed that increasing body fat may enhance inflammatory mediators, thereby contributing to the severity of menstruation discomfort, supports the association between increased adiposity and dysmenorrhea found in the current study [14].

Additionally, the study discovered a strong correlation between early menarche and poor menstrual health outcomes like irregular periods and more intense pain. This is in line with research by Lakshman *et al*., who found that early menarche is linked to an increased risk of reproductive health issues, such as hormonal imbalances and irregular menstruation [15]. Furthermore, early maturation may expose girls to protracted hormonal oscillations, raising the risk of menstrual problems and psychological stress, as noted by Mendle *et al*. [16].Similar results were found in an Indian study by Pathak *et al*. among teenage females in Uttar Pradesh, where early menarche was linked to greater BMI and a higher frequency of menstruation issues [17].

The interaction of biological and lifestyle factors can account for the study's findings. Adolescent obesity has increased due to dietary changes, decreased physical activity, and increased urbanization. This has an impact on hormone control and reproductive development. The noted correlations emphasize how crucial it is to take developmental timing and nutritional condition into account when evaluating the reproductive health of adolescents.

However, there are some limitations that should be taken into consideration when interpreting the results. Self-reported menstruation data may introduce recollection bias, and the cross-sectional design limits the capacity to establish casual correlations. Notwithstanding these drawbacks, the study offers insightful information about how menarcheal timing and anthropometric markers interact to affect menstrual health.

Overall, the current study adds localized data from North 24 Parganas and is consistent with national and international research. In order to lessen the burden of menstrual health issues and enhance long-term health outcomes, it emphasizes the necessity of early screening, nutritional interventions, and reproductive health education programs aimed at adolescent girls.

6. Conclusion

Among teenage girls in North 24 Parganas, West Bengal, the current study reveals a strong correlation between menarcheal age, anthropometric markers, and menstrual health traits. Higher levels of overall and central adiposity, as measured by BMI, waist circumference, and waist-hip ratio, are linked to an earlier menarche as well as a higher frequency of irregular menstruation, altered menstrual flow patterns, and more severe pain.

Menarcheal timing has also been shown to be a significant predictor of menstrual health outcomes; irregular cycles and increased dysmenorrhea are more commonly

associated with early menarche. These findings imply that reproductive health during adolescence is significantly influenced by both biological maturation and body composition.

The study emphasizes how crucial it is for adolescent health program to incorporate anthropometric assessment with menstrual health assessments. Long-term reproductive and metabolic problems can be avoided by early identification of at-risk individuals through school-based screening and awareness programs.

In order to support adolescent girls' optimal growth and well-being, the results highlight the necessity of focused interventions that emphasizes balanced diet, health lifestyle choices, and reproductive health education. It is recommended that future longitudinal studies investigate the long-term effects of early menarche and obesity on women's health in order to determine casual links.

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