RESEARCH PAPER

Association of Age at Menarche with Body Mass Index among Adolescent Girls - A Cross-Sectional Study

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Abstract

Background: Age at menarche is a key milestone in female reproductive development and is influenced by genetic, nutritional, and environmental factors. Increasing prevalence of childhood and adolescent obesity has raised alarms regarding its impact on pubertal timing.

Objectives: To assess the average age at menarche among adolescent girls and to evaluate its association with body mass index (BMI), along with selected socioeconomic and lifestyle factors.

Methods: A cross-sectional study was conducted among 200 adolescent girls aged 10–16 years who had attained menarche. Data regarding age at menarche were collected using a structured questionnaire. Height and weight were measured, and BMI was calculated and classified according to World Health Organization (WHO) criteria. Statistical analysis included descriptive statistics, Pearson correlation, and multivariable linear regression to assess the association between BMI and age at menarche.

Results: Among the 200 adolescent girls, the mean age at menarche was 12.3 ± 1.1 years and the mean BMI was 19.8 ± 3.4 kg/m². A significant inverse correlation was observed between BMI and age at menarche ($r = -0.42$, $p < 0.001$). Frequent consumption of junk or fast food was also associated with earlier menarche ($r = -0.31$, $p < 0.001$), while regular physical activity showed a positive association with later onset of menarche ($r = 0.28$, $p = 0.002$). On multivariable linear regression analysis, BMI emerged as the strongest independent predictor of age at menarche, with each unit increase in BMI associated with a 0.16-year reduction in age at menarche ($p < 0.001$), even after adjusting for dietary pattern, physical activity, and socioeconomic status.

Conclusion: Higher BMI is significantly associated with earlier onset of menarche. These findings highlight the importance of maintaining healthy body weight during childhood and adolescence to promote optimal reproductive health outcomes.

Keywords: Menarche, Body Mass Index, Adolescents, Puberty, Reproductive Health

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Introduction

Menarche, defined as the first menstrual bleeding, represents a pivotal event in female pubertal development and reproductive maturation. The timing of menarche is determined by a complex interaction of genetic, nutritional, environmental, and socioeconomic factors. Over recent decades, a global secular trend toward earlier age at menarche has been observed, coinciding with rising prevalence of childhood and adolescent overweight and obesity [1,2]. Body mass index (BMI) has emerged as one of the most consistent modifiable determinants of pubertal timing. Adipose tissue functions as an active endocrine organ, producing leptin and other adipokines that influence activation of the hypothalamic–pituitary–gonadal axis, thereby accelerating pubertal onset in girls with higher adiposity [3–5]. Early menarche has been linked to several adverse long-term outcomes, including polycystic ovary syndrome, metabolic syndrome, type 2 diabetes mellitus, cardiovascular disease, and hormone-dependent

malignancies [6-8]. Despite substantial international literature demonstrating an inverse association between BMI and age at menarche, population-level variations exist due to differences in ethnicity, nutritional patterns, socioeconomic status, and lifestyle factors. In low- and middle-income countries such as India, the coexistence of undernutrition and obesity creates a unique dual burden, particularly among adolescents. Indian studies on menarcheal age have reported wide variability, and many are limited by small sample sizes or lack of adjustment for confounding factors such as physical activity and socioeconomic status [4]. With increasing urbanization, sedentary behavior, and changing dietary patterns among Indian adolescents, there is a growing concern regarding early pubertal onset and its health implications. Understanding the association between BMI and age at menarche in the local population is essential for early identification of at-risk girls and for designing preventive strategies focused on healthy growth and development. There is a paucity of recent, institution-based data from South India examining the relationship between BMI and age at menarche using standardized anthropometric measurements and incorporating socioeconomic and lifestyle variables. Moreover, limited data are available at the postgraduate research level that can be translated into clinical and public health practice. Hence, this study aims to determine the mean age at menarche among adolescent girls aged 10–16 years, and to evaluate the association between BMI,diet and age at menarche.

Materials and Methods

This cross-sectional study was conducted in the Department of Obstetrics and Gynaecology at Sree Balaji Medical College and Hospital, Chennai, and in selected nearby schools and community settings. Adolescent girls aged 10–16 years who had already attained menarche were enrolled after obtaining written informed consent from parents or guardians and assent from participants. Girls with known endocrine or metabolic disorders, history of eating disorders, recent significant weight changes, or use of hormonal medications in the preceding six months were excluded. Data were collected using a pretested structured questionnaire that recorded sociodemographic details, age at menarche, dietary habits, and physical activity patterns. Dietary intake was broadly categorized into predominantly home-cooked balanced diet, mixed diet with frequent consumption of energy-dense foods, and predominantly junk/fast food–based diet. Physical activity was classified as regular, occasional, or sedentary. Height and weight were measured using standardized techniques, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. BMI was categorized according to World Health Organization criteria. Data were entered into Microsoft Excel and analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Associations between BMI, nutritional factors, and age at menarche were assessed using Pearson correlation, analysis of variance, and multivariable linear regression. A p-value of less than 0.05 was considered statistically significant. Ethical clearance was obtained from the Institutional Ethics Committee, and confidentiality of all participants was strictly maintained.

Results

A total of 200 adolescent girls who had attained menarche were included in the analysis. The mean age of the participants was 13.2 ± 1.4 years, and the mean age at menarche was 12.3 ± 1.1 years. The overall mean body mass index (BMI) was 19.8 ± 3.4 kg/m².

Baseline Characteristics of the Study Participants

Baseline demographic and anthropometric characteristics of the participants are summarized in Table 1. More than half of the participants (52%) had normal BMI, while 18% were underweight, 20% were overweight, and 10% were obese. With regard to lifestyle factors, 46% reported consumption of a predominantly home-cooked balanced diet, whereas 20% reported frequent intake of junk or fast foods. Regular physical activity was reported by 38% of participants.

Table 1. Baseline characteristics of the study participants

Variable	n (%) / Mean ± SD **(n = 200)**
Age (years)	13.2 ± 1.4
Age at menarche (years)	12.3 ± 1.1
BMI (kg/m²)	19.8 ± 3.4
Underweight	36 (18)
Normal BMI	104 (52)
Overweight	40 (20)
Obese	20 (10)
Balanced home diet	92 (46)
Mixed diet	68 (34)
Junk/fast food predominant	40 (20)
Regular physical activity	76 (38)
Occasional activity	84 (42)
Sedentary lifestyle	40 (20)

Distribution of Risk Factors for Early Menarche

Participants with higher BMI categories, junk or fast food–predominant diets, and sedentary lifestyles demonstrated a lower mean age at menarche compared to their counterparts. Overweight and obese participants attained menarche nearly one year earlier than underweight participants. Similarly, girls consuming junk or fast food frequently and those with sedentary lifestyles showed earlier onset of menarche.(Table-2)

Table 2. Distribution of risk factors and mean age at menarche

Risk factor	Category	Mean age at menarche (years) ± SD
BMI	Underweight	12.9 ± 1.0
	Normal	12.4 ± 0.9
	Overweight	11.9 ± 0.8
	Obese	11.5 ± 0.7
Diet pattern	Balanced	12.6 ± 0.9
	Mixed	12.2 ± 0.8
	Junk/fast food	11.7 ± 0.7
Physical activity	Regular	12.7 ± 0.9
	Occasional	12.3 ± 0.8
	Sedentary	11.8 ± 0.7

Association Between BMI, Nutritional Factors, and Age at Menarche

In study demonstrated a statistically significant inverse association between BMI and age at menarche. Pearson correlation analysis revealed a moderate negative correlation between BMI and age at menarche ($r = -0.42$, $p < 0.001$). Dietary pattern characterized by frequent junk or fast food intake also showed a significant negative correlation with age at menarche ($r = -0.31$, $p < 0.001$). Physical activity demonstrated a positive correlation, with higher activity levels associated with later menarche ($r = 0.28$, $p = 0.002$).(Table-3)

Table 3. Correlation between selected variables and age at menarche

Variable	Correlation coefficient (r)	p-value
BMI	−0.42	<0.001
Junk/fast food intake	−0.31	<0.001
Physical activity	0.28	0.002

Multivariable Inferential Analysis

On multivariable linear regression analysis adjusting for socioeconomic status, dietary pattern, and physical activity, BMI emerged as the strongest independent predictor of age at menarche. Each unit increase in BMI was associated with a reduction of 0.16 years in age at menarche. Junk or fast food–predominant diet and sedentary lifestyle also remained significant predictors of earlier menarche.(Table-4)

Table 4. Multivariable linear regression analysis for predictors of age at menarche

Variable	β coefficient	95% CI	p-value
BMI (kg/m²)	−0.16	−0.22 to −0.10	<0.001
Junk/fast food diet	−0.12	−0.20 to −0.04	0.004
Sedentary lifestyle	−0.09	−0.17 to −0.02	0.02
Socioeconomic status	−0.07	−0.13 to −0.01	0.03

Overall, higher BMI, poor dietary quality, and reduced physical activity were independently associated with earlier onset of menarche among adolescent girls. Dietary pattern also showed a significant association with age at menarche. Girls consuming junk or fast food frequently attained menarche earlier than those consuming predominantly home-cooked balanced diets.

DISCUSSION

The present cross-sectional study demonstrates a statistically significant inverse association between body mass index (BMI) and age at menarche among adolescent girls. Participants with higher BMI, particularly those in the overweight and obese categories, attained menarche at an earlier age compared to underweight and normal-weight girls. These findings are consistent with a growing body of evidence suggesting that increased adiposity accelerates pubertal onset. Similar observations have been reported in international studies. Afkhamzadeh et al. documented a significantly lower mean age at menarche among Iranian schoolgirls with higher BMI and better socioeconomic status, highlighting the influence of nutritional status on pubertal timing [1]. Likewise, Asrullah et al., using nationally representative longitudinal data from Indonesia, demonstrated a declining trend in age at menarche that closely paralleled increasing body weight and BMI over time [2]. Studies from the Middle East have also reported earlier menarche

among overweight adolescents, reinforcing the consistency of this association across diverse populations [3]. Indian studies corroborate these findings. Sinha et al. reported that overweight and obese adolescent girls attained menarche nearly one year earlier than girls with normal BMI, emphasizing the impact of nutritional transition and urban lifestyle changes in India [4]. The mean age at menarche observed in the present study (12.3 ± 1.1 years) is comparable to recent Indian data and suggests a gradual decline compared to earlier decades, possibly due to improved nutrition, increased caloric intake, and reduced physical activity.

The biological basis for this association is well established. Adipose tissue functions as an active endocrine organ and secretes leptin, which plays a crucial permissive role in the initiation of puberty by stimulating gonadotropin-releasing hormone secretion. Kaplowitz emphasized that while a minimum fat mass is required for pubertal onset, excess adiposity may accelerate pubertal maturation [5]. Additionally, obesity-related hormonal alterations such as hyperinsulinemia and changes in adipokine signaling have been shown to contribute to early activation of the hypothalamic–pituitary–gonadal axis [6]. Dietary pattern emerged as an important modifiable risk factor in the present study. Girls consuming junk or fast food–predominant diets attained menarche at an earlier age compared to those consuming balanced home-cooked diets. Similar associations have been reported in studies from Iran, Indonesia, and Saudi Arabia, where frequent consumption of energy-dense, nutrient-poor foods was linked to higher BMI and earlier pubertal onset [1–3]. These dietary patterns contribute to positive energy balance and increased adiposity, thereby influencing pubertal timing. Physical activity demonstrated a protective effect in the present study, with regularly active girls attaining menarche at a later age compared to those with sedentary lifestyles. Saputra et al. observed delayed pubertal onset among rural children with higher levels of physical activity compared to urban children, supporting the role of lifestyle factors in pubertal development [9]. Reduced physical activity contributes to fat accumulation and may indirectly influence hormonal pathways involved in menarche. Multivariable regression analysis in the present study identified BMI as the strongest independent predictor of age at menarche, even after adjusting for dietary pattern, physical activity, and socioeconomic status. This finding reflects results from large cohort studies, including the ELSA-Brasil study, which identified early menarche as a marker of future cardiometabolic risk independent of confounding variables [7,8]. The clinical significance of early menarche lies in its established association with adverse long-term outcomes such as polycystic ovary syndrome, metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease. Despite its strengths, the study has certain limitations. The cross-sectional design limits causal inference, and age at menarche was self-reported, which may be subject to recall bias. Dietary intake was assessed using broad categories rather than detailed dietary recall. Nevertheless, the study provides valuable institution-based data from South India and strengthens existing evidence by simultaneously evaluating BMI, dietary pattern, and physical activity in relation to age at menarche.

Conclusion

Higher body mass index, unhealthy dietary patterns characterized by frequent junk or fast food consumption, and sedentary lifestyle are significantly associated with earlier age at menarche among adolescent girls. Body mass index remains the strongest independent predictor even after adjusting for potential confounders. Early identification of girls at risk and promotion of healthy dietary habits and physical activity during childhood and adolescence may help to optimize pubertal timing and reduce future reproductive and metabolic health risks.

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Conflict of Interest

The authors declare no conflict of interest.

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