

Systematic Literature Review

The Association Between Body Mass Index (BMI) and Age of Menarche in Adolescents

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A B S T R A C T

Adolescence is a critical transitional period characterized by rapid physical and reproductive maturation. One of the primary indicators of female pubertal development is menarche, the first menstrual period, which reflects the functional maturation of the reproductive system. In recent decades, the age at menarche has shown a declining trend globally, potentially influenced by changes in lifestyle and nutritional status. Body Mass Index (BMI) is commonly used to assess nutritional status and has been identified as an important determinant of pubertal timing. This study aimed to systematically analyze the relationship between BMI and age at menarche through a systematic review approach. A literature search was conducted in two databases, Google Scholar and PubMed, identifying a total of 2,198 articles published between 2020 and 2024, selected using PRISMA guidelines. After screening and eligibility assessment, 11 articles met the inclusion criteria and were included in the final analysis. The findings consistently demonstrate a statistically significant association between higher BMI and earlier menarche ($p < 0.05$). Early menarche is associated with long-term health risk, including cardiovascular disease, metabolic disorders, and certain cancers. BMI plays a significant role in determining the timing of menarche. Maintaining optimal nutritional status during adolescence is essential to support balanced reproductive development and long-term health outcomes.

INTRODUCTION

Reproductive health refers to the physical, mental, and social well-being in all matters relating to the reproductive system and its functions. It enables individuals to function productively and maintain a good quality of life throughout different stages of development. Adolescence represents a critical phase in the life cycle, characterized by rapid biological, psychological, and social transitions. According to the WHO, adolescence begins at 10 years and continues until 19 years old (World Health Organization, 2024). According to Regulation No. 5 of 2014 by the Minister of Health of The Republic of Indonesia, adolescence is defined as individuals aged between 10 and 18 years. Meanwhile, the National Population and Family Planning Board (BKKBN) extends this definition to individuals aged 10 to 24 years who are not married (Alam & Syahrir, 2021). These variations in definitions highlight the importance of adolescence as a strategic period for reproductive health interventions and monitoring.

Menarche, defined as the first menstrual period, represents a significant milestone in female reproductive development. It marks the maturation of the reproductive system and signifies transition from childhood to adulthood (Hadi & Atiqa, 2021). The onset of menarche reflects complex interactions between genetic predisposition, environmental exposure, hormonal regulation, and nutritional status. Among these factors, nutritional status plays a central role because it directly influences hormonal activity and physical growth. Body Mass Index (BMI) is widely used as an anthropometric indicator to assess nutritional status and has been identified as one the key determinants influencing the timing of menarche (Mutayasa et al., 2016).

In Indonesia, the age at menarche varies between 10 and 16 years, with an average age of approximately 12.5 years. This variation may be influenced by hormonal mechanisms, particularly leptin, an adipocyte derived hormone produced by body fat tissue. Leptin plays an essential role in regulating energy balance and stimulating the hypothalamic pituitary gonadal axis, thereby influencing the early stages of puberty (Yuliasuti, 2015). Adequate energy reserves signaled by leptin are necessary to initiate reproductive maturation, explaining why differences in body fat composition may contribute to variations in menarche.

Over the past decade, there has been a noticeable global and national trend toward earlier menarche. Data from the 2018 Basic Health Research (Riskesdas) indicate a declining trend in the average age at menarche among Indonesian adolescents, decreasing from 13 years in 2012 to 12.8 years in 2018. Some adolescent also experienced menarche before the age of 9, while others experienced it later, up to age 17. According to this data, Indonesia ranks 15th out of 67 countries, which indicates that the menarche age is declining by 0.145 years every ten years (Kemenkes RI, 2018; Putra et al., 2016).

This declining trend may be associated with rapid lifestyle changes, including increased caloric intake, reduced physical activity, and a growing prevalence of overweight and obesity among adolescents. The improvement in socioeconomic conditions and dietary patterns has contributed to earlier biological maturation. Therefore, nutritional status has become one of the most important modifiable factors influencing pubertal timing.

Body Mass Index (BMI) is widely used an anthropometric indicator to assess nutritional status and has been identified as one of the key determinants influencing the timing of menarche (Putra et al., 2016). BMI is associated with the onset of menarche in female adolescents. Adolescent girls with excess BMI (overweight) tend to experience early menarche compared to those with normal or low BMI (underweight).

A study by Alam found correlation between the age of menarche with nutritional status in female adolescents at SMPN 10 Bulukumba, Ujung Loe District, Bulukumba Regency, with a p-value = 0.020 and an odds ratio (OR) = 4.28 (Alam & Syahrir, 2021). According to a study by Minerva et al, the earliest menarche onset was at age 9, while the latest was at age 15. The majority of the participants developed menarche at ages 12 (35.8%) and 13 (30.4%). At the age of 12, 57.8% of girls had already undergone menarche, and this percentage rose to 88.2% by age 13. By age 14, about 99.5% of the girls had undergone menarche (Kadir et al., 2019).

Early menarche may elevate the risk of several health complications, including breast cancer and endometrial cancer, as a result of extended estrogen exposure (Gong et al., 2015). Moreover, it has been linked to a higher risk of metabolic syndrome, diabetes, and cardiovascular diseases and may also elevate mortality rates from ischemic heart disease and stroke (Lee et al., 2019).

LITERATURE REVIEW

Adolescence and Reproductive Health

Adolescence is a transitional phase from childhood to adulthood characterized by biological, psychological, and social changes. According to the World Health Organization (WHO, 2024), adolescence ranges from 10 to 19 years of age. In Indonesia, adolescence is defined in national regulations, including Regulation No. 5 of 2014 by the Minister of Health of the Republic of Indonesia, which states that adolescents are individuals age 10-18 years. Furthermore, the National Population and Family Planning Board (BKKBN) defines adolescents as individuals age 10-24 years who are unmarried (Alam & Syahrir, 2021).

Reproductive health refers to a state of complete physical, mental, and social well-being related to the reproductive system and its functions. Adolescence is a critical period for reproductive health because reproductive organ maturation occurs during this phase, influenced by significant hormonal changes.

Menarche as an Indicator of Puberty

Menarche is the first menstrual period and marks the maturation of female reproductive function (Hadi & Atiqa, 2021). The age at menarche varies among individuals and is influenced by genetic, nutritional, environmental, physical activity, and socioeconomic factors (Putra et al., 2016). In Indonesia, data show a declining trend in the average age of menarche

over the past decade. According to the 2018 Basic Health Research (Riskesdas), the average of menarche decreased from 13 years in 2012 to 12.8 years in 2018.

Physiologically, menarche occurs through the activation of the hypothalamic pituitary gonadal (HPG) axis. The hypothalamus releases Gonadotropin Releasing Hormone (GnRH), which stimulates the anterior pituitary gland to secrete Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH). These hormones stimulate the ovaries to produce estrogen, triggering the development of secondary sexual characteristics and the onset of menstruation (Childs et al., 2021).

The critical body fat hypothesis suggests that a minimum percentage of body fat is required for the initiation of menstruation. Girls with higher fat accumulation tend to reach this threshold earlier, accelerating pubertal development. Conversely, undernutrition may delay activation of the HPG axis due to insufficient energy reserves.

Body Mass Index (BMI) and Nutritional Status

Body Mass Index (BMI) is an anthropometric indicator used to assess nutritional status based on weight (kg) divided by height squared (m²). BMI is classified as follows:

1. BMI < 18.4: Underweight
2. BMI 18.5-25.0: Normal
3. BMI > 25.1: Overweight/Obese

BMI is widely used in public health research due to its simplicity and effectiveness in reflecting body fat reserves (Mutayasa et al., 2016). Adequate nutritional status plays an essential role in supporting adolescent growth and reproductive system maturation.

BMI and Age at Menarche

Numerous studies have demonstrated a significant association between BMI and age at menarche. Alam & Syahrir (2021) reported a significant correlation between nutritional status and age at menarche ($p=0.020$; OR-4.28), indicating that adolescents with higher BMI are more likely to experience early menarche. Kadir et al. (2019) found that most adolescents experienced menarche at ages 12-13 years, with a higher proportion among those with higher BMI. Similarly, an international study conducted in China reported a significant relationship between BMI and age at menarche, with an average menarche age of 13.3 years (Wang et al., 2016)

Biologically, increased adipose tissue enhances leptin secretion, a hormone that regulates energy balance and stimulates GnRH release from the hypothalamus. Leptin signals adequate energy reserves to initiate puberty, explaining why adolescents with higher BMI tend to experience earlier menarche (Childs et al., 2021).

METHOD

This study employed a systematic review design to examine the association between Body Mass Index (BMI) and age at menarche among adolescent girls. The review was conducted systematically using two electronic databases, Google Scholar and PubMed. The search was conducted for studies published between 2020 and 2024. The keywords used in the search strategy included "Body Mass Index," "BMI," "Age at Menarche," "Early Menarche," and "adolescent girls." Boolean operators (AND, OR) were applied to refine the search results.

The inclusion criteria were: (1) original research articles; (2) studies involving adolescent girls aged 10-19 years; (3) studies analyzing the relationship between BMI and age at menarche; (4) articles published in English or Indonesian; and (5) full-text articles accessible online. The exclusion criteria were: (1) review articles, editorials, or case reports; (2) duplicate publications; and (3) studies with incomplete or unclear data.

The selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Initially, all identified articles were screened based on titles and abstracts. Relevant articles were then assessed for full-text eligibility. After applying the inclusion and exclusion criteria, 11 studies were selected and analyzed in this review. Data extraction focused on study design, sample characteristics, BMI classification, age at menarche, statistical analysis, and key findings. The findings were synthesized descriptively to identify patterns and consistency across studies.

In addition, the methodological quality of the included studies was assessed using a simple evaluation checklist that considered study design, sample size, clarity of outcome measurement, and appropriateness of statistical analysis.

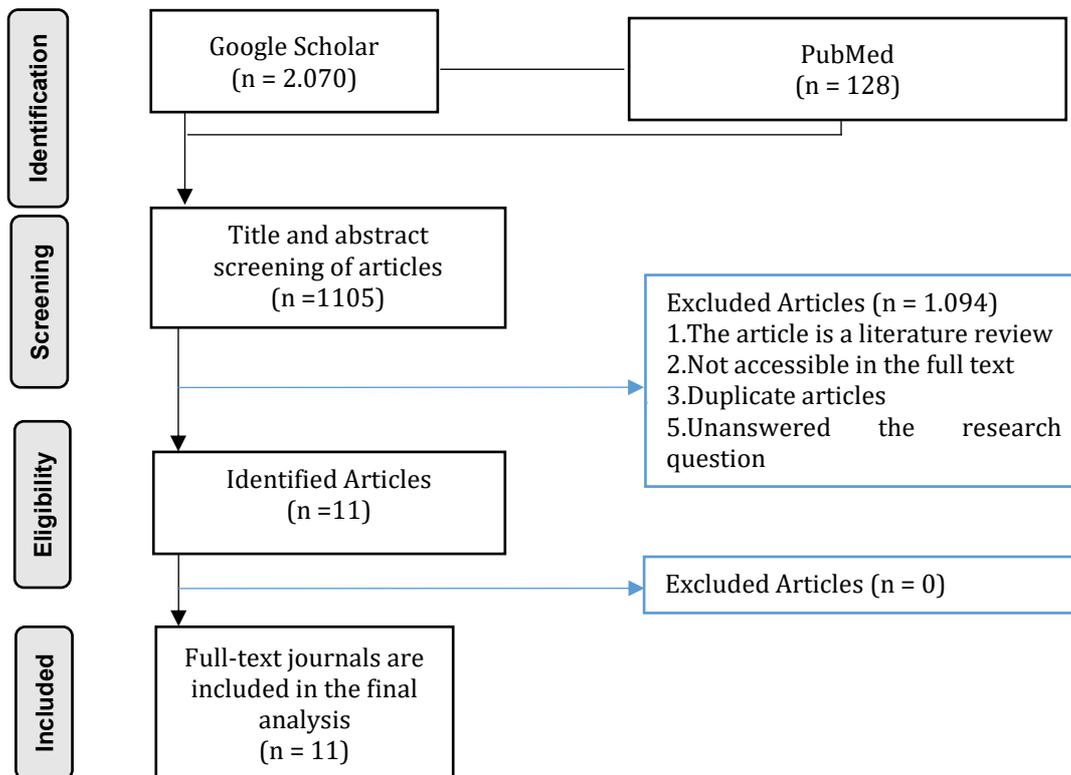


Figure 1. PRISMA Flow Chart

RESULT AND DISCUSSION

The findings of this systematic review demonstrate a consistent and statistically significant association between BMI and age at menarche. The biological mechanism underlying this relationship is primarily mediated through leptin signaling and earlier activation of the hypothalamic pituitary gonadal axis. Higher adiposity results in increased estrogen production through peripheral aromatization, further contributing to earlier reproductive maturation.

Table 1. Summary of Included Studies

No	Title	Objective	Results
1	The Correlation Between Body Mass Index (BMI) and Early Menarche at SMPN 1 Sumber, Cirebon Regency, Age 12-15 years (Rahmananda & Sari, 2020)	Analyzing correlation between BMI and menarche in the age group of 12-15 years	Students with a higher BMI (overweight) were more likely to experience early menarche compared to those with normal or underweight status. A significant correlation was observed between BMI and early menarche. The study revealed that overweight girls in the sample experienced menarche at a younger age, with an average onset of 11.5 years,
2	The Relationship Among Body Mass Index (BMI) and Menarche Age in Adolescent Girls in Tigo Nagari District, Prasmanan Regency (Saputri et al., 2021)	Examine correlation BMI with age of menarche in adolescent girls in Tigo Nagari District, Pasaman Regency.	The study found a significant relationship between BMI with age of menarche. Adolescent with higher BMI (overweight/obese) tended to experience menarche earlier, with an average age of menarche at 11.8 years. P-value<0.05, indicating a significant correlation between BMI and menarche age.
3	Relationship Between Body Mass Index (BMI) and Age of	Investigate the correlation between	The study found a significant correlation with statistical tests revealed a p-value < 0.05. Female

	Menarche in Female Students of SDN 44, Bima City (Febriyanti, 2021)	BMI with the age of menarche in female students at SDN 44, Bima City.	students with higher BMI (overweight/obese) tended to experience menarche at an earlier age (average age 11.5 years), compared to those in the normal BMI category (average age 12.1 years).
4	The relationship Between Body Mass Index (BMI) and Age of Menarche in Eighth Grade Female Students at SMP Negeri 07 Seluma (Oklani et al., 2022)	Examine correlation between BMI with age of menarche in eighth-grade female student	The study indicated a relationship between BMI with the age of menarche. Female students with higher BMI (overweight/obese) tended to experience menarche earlier (average age 11.9 years), while those with normal BMI experienced menarche at an older age (average age 12.5 years)
5	Relationship Between Body Mass Index and Age of Menarche in Adolescent Girls At MTs Negeri 3 Gorontalo Regecy (Adam et al., 2022)	Explore the correlation the body mass index (BMI) with the age of menarche in adolescent girls	Preliminary results indicated that adolescent girls with a higher BMI (overweight/obese) tended to experience menarche earlier compared to those with normal or lower BMI. Specifically, girls with BMI in the overweight/obese range experienced menarche at an average age of 11.7 years, while those with normal BMI experienced menarche at an average age of 12.3 years. The chi-square test showed a significant correlation between BMI and menarche ($p < 0.05$).
6	Correlation Among Body Mass Index (BMI) and Age of Menarche in Female Students at SMP Negeri 1 Katolik Ori, North Nias Regency (Tarigan, 2023)	Analyzing BMI and the age of menarche in female students at SMP Negeri 1 Katolik Ori.	The majority of female students who experienced early menarche (≤ 12 years) had a higher BMI (overweight/obesity), while those who experienced delayed menarche (≥ 14 years) tended to have a normal BMI or even lower (underweight). Statistical analysis showed a significant relationship between BMI and age of menarche ($p < 0.05$).
7	The Relationship Among Nutritional Status and Age of Menarche in Female Student at Manado Independent School (Monica & Herdiman, 2023)	Investigating the correlation nutritional status, as measured by BMI, with the age of menarche	The findings revealed a significant relationship between BMI and the age of menarche. Girls with higher BMI (overweight/obesity) tended to experience earlier menarche, while those with lower BMI (underweight) experienced delayed menarche. Statistical analysis showed a significant association ($p = 0,03$).
8	The Relationship Between Nutritional Status and Age of Menarche in Adolescent Girls at SMPN 5 Kendari (Amiruddin et al., 2023)	Examine correlation nutritional status with the age of menarche in adolescent girls at SMPN 5 Kendari	Adolescent girls with higher BMI (overweight or obese) tended to experience menarche in earlier age compared to those with normal or underweight BMI. Statistical analysis revealed a significant relationship with p-value of 0.02, indicating that nutritional status affects the timing of menarche.
9	The Relationship Between Nutritional Status and Age of Menarche in Female Students of SMP in Ngada District (Noa et al., 2024)	Analyzing the relationship nutritional status, as measured by BMI, with the age of menarche	The chi-square test yielded a p-value = 0.002, indicating significant correlation between nutrition (BMI measured) with the age of menarche.
10	Correlation of Body Mass Index levels with Menarche in adolescent girls in shaanxi, China: a cross sectional study.(Wang et al., 2016)	Investigate the correlation BMI levels and the age of menarche in adolescent girls in Shaanxi, China.	The study found a statistically significant correlation between BMI levels and the age of menarche. Girls in the overweight/obese category experienced menarche at a younger age (average 11.9 years) compared to those in the normal weight category (average 12.6 years).
11	Relationship Among Body Mass Index (BMI) with Age of Menarche in Adolescents at	Examine the relationship between BMI with	The results revealed a significant correlation BMI and menarche. Adolescent girls with higher BMI (overweight and obese) were more likely to experience

SMPN Abulyatama, Kuta Baro District, Aceh Besar Regency, Aceh Province (Wandari et al., 2024)	menarcho among earlier adolescent girls menarcho (11.5 years), while those with lower BMI (underweight) had a delayed onset of menarcho. The statistical analysis (chi-square test) $p = 0.013$.
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Nutritional status is a factor affecting the age of menarcho in adolescent females. Adolescence necessitates adequate nutrition, as adolescents represent the next generation tasked with shaping a better and more prosperous future. Adolescent girls with good nutritional status show a faster growth rate during the prepubertal phase compared to those who suffer from nutritional deficiencies. To assess nutritional status in adolescents, one of the methods used is the measurement body mass index (BMI) (Proverawati, 2009).

Multiple research studies indicate that a high body mass index (BMI) correlates with early menarcho. A study in Indonesia found that teenage females with high nutritional status (BMI) experienced menarcho at an earlier age (11.25 years) than those with normal (12.56 years) and inadequate status (13.13 years) (Kadir et al., 2019). An Indonesian study also revealed a correlation the age of menarcho with nutritional status. Statistical test results showed a $P=0.000$, indicating a strong relationship. The study concluded that adolescents with better nutritional status tend to experience earlier menarcho compared to those with poor nutritional status (Arifin et al., 2020).

In Iran, the prevalence of early menarcho (≤ 11 tahun) and delayed menarcho (≥ 13 tahun) has been observed (Hozoori et al., 2017). In Norway, the average age of menarcho is 13.1 years (Bratke et al., 2017). While, in China, it is 13.3 years (Wang et al., 2016). In Korea, there are groups with early menarcho (≤ 12 years) and groups with delayed menarcho (>12 years). The early menarcho in Kuwait is defined as equivalent to age ≤ 11 years, while the average menarcho age is 12.41 years (Al-Awadhi et al., 2013). In Saudi Arabia, early menarcho occurs at ≤ 12 years, while delayed menarcho occurs at ≥ 15 years (Rafique & AlSheikh, 2019). These variations in the age at menarcho across countries may be influenced by differences in dietary habits, nutritional status, genetic or ethnic backgrounds, socioeconomic conditions, and lifestyle factors that affect hormonal regulation and pubertal development

The increase in body fat maybe one of the factors involved in this process, through the secretion of the leptin protein produced by adipose tissue. As a result of leptin, the hypothalamus releases more gonadotropin-releasing hormone, and at the same time, the pituitary gland makes LH (luteinizing hormone) and FSH (follicle stimulating hormone). It also stimulates the adrenal glands to produce gonadocorticoid hormones, which regulate sex hormones (Childs et al., 2021).

Adolescent girls need to understand the importance of balanced nutrition to support the maturation of reproductive organs. Inadequate nutritional intake might hinder the maturation of sexual functioning and may pose a risk factor for disease development in adulthood, such as cardiovascular diseases, diabetes, cancer, and osteoporosis (Febriyanti, 2021).

CONCLUSION

The results indicate a significant correlation between BMI with menarcho. Early menarcho occurring at age ≤ 12 years, while late menarcho accours at age ≥ 15 years. The prevalence of menarcho is significantly higher in overweight adolescent females compared to their counterparts with a normal or underweight BMI in the same age group.

The nutritional status of adolescent girls has a significant impact on the timing of the menarcho. Both undernutrition and overnutrition can lead to either an accelerated or delayed onset of menarcho. Therefore, adolescent girls need to maintain a normal or ideal BMI range (18.5-25.0). Excessive consumption of junk food and lack of physical activity can increase the risk of overweight or obesity. On the other hand, undernutrition in adolescent girls can hinder reproductive health development, including delayed menarcho.

RECOMMENDATION

The government or stakeholders, particularly in the healthcare sector, should provide health education on enhance adolescent girls' knowledge about healthy lifestyles. This includes the consumption of healthy meals, a decrease in excessive sugar intake, regular physical activity, enough sleep, dietary management, and stress management to prevent problems related to the early menarcho.

According to the search findings, there is currently little study on BMI and menarche age due to cross-sectional design and small sample numbers. These limitations reduce the ability to generalize the research results and do not provide causal evidence. To make the results more general, it is suggested that future research use the Randomized Controlled Trial (RCT) method with larger sample size and both control and intervention groups.

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