SEHATMAS (Jurnal Ilmiah Kesehatan Masyarakat)
https://journal.literasisains.id/index.php/SEHATMAS
e-ISSN 2809-9702 | p-ISSN 2810-0492
Vol. 5 No. 3 (Juli 2026) 843-850
DOI: 10.55123/sehatmas.v5i3.8423
Submitted: 02-06-2026 | Accepted: 10-07-2026 | Published: 15-07-2026

The Relationship Between Nutritional Status and Early Menarche: A Narrative Review

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Abstract

This narrative review examines the relationship between nutritional status and the timing of menarche in adolescent girls, with a particular focus on early menarche. It explores how nutritional status influences pubertal onset and the associated health risks amid the increasing global prevalence of childhood overweight. A literature search of studies published between 2015 and 2025 was conducted using PubMed, Google Scholar, and ScienceDirect, resulting in five eligible cross-sectional studies from Brazil and Indonesia. The findings consistently indicate that higher body mass index (BMI) is significantly associated with menarche before age 12, potentially through hormonal mechanisms involving leptin and activation of the hypothalamic–pituitary–gonadal axis. Early menarche is associated with greater risks of metabolic, reproductive, and psychosocial health problems. Public health interventions should promote balanced nutrition, regular physical activity, and routine growth monitoring to support healthy pubertal development. Further longitudinal studies are needed to establish causal relationships and identify additional factors influencing the timing of menarche.

Keywords: *Adolescent Girl, Early Menarche, Nutritional Status, BMI.*

INTRODUCTION

Adolescence is a crucial transitional phase from childhood to adulthood, marked by significant biological, psychological, and social changes. One of the most important events in the life cycle of adolescent girls is the onset of menstruation, or menarche, which signifies the beginning of reproductive capability. Menarche serves as an important indicator of pubertal development, physical maturity, nutritional status, and reproductive health in adolescent girls(Ibitoye et al., 2017). Physiologically, menarche refers to the first menstrual bleeding caused by the shedding of the endometrial lining, indicating that the reproductive system has started functioning. Typically, menarche occurs between the ages of 12 and 14. If it occurs before the age of 12, it is referred to as early menarche, which is commonly triggered by an earlier-than-normal increase in estrogen production (Ade et al., 2025).

From a biological perspective, menarche is the result of the activation of the hypothalamic–pituitary–gonadal (HPG) axis, a neuroendocrine system that regulates sexual maturation and reproductive function(Spaziani et al., 2021). The process begins with the pulsatile release of gonadotropin-releasing hormone (GnRH) from the hypothalamus, which stimulates the anterior pituitary to secrete luteinizing hormone (LH)

and follicle-stimulating hormone (FSH). These gonadotropins act on the ovaries to produce estrogen, leading to the development of secondary sexual characteristics and the initiation of menstrual cycles. The timing of this hormonal activation is influenced by metabolic signals, particularly leptin, a hormone produced by adipose tissue. Leptin functions as a permissive signal to indicate adequate energy reserves for reproduction, linking nutritional status to the onset of puberty.

The increasing prevalence of overweight and obesity among adolescents has become a major public health concern worldwide. According to the World Health Organization (WHO), the prevalence of overweight (including obesity) among children and adolescents aged 5-19 years increased from 8% in 1990 to 20% in 2022, affecting more than 390 million individuals globally, including 160 million living with obesity (WHO, 2025). In Indonesia, a similar trend has been observed. WHO country estimates reported that the prevalence of obesity among children and adolescents aged 5–19 years reached 10.8% in 2022 and continued to show an increasing trend compared with previous years (WHO, 2025). This growing burden of overnutrition is particularly important because excess adiposity may influence pubertal development through hormonal mediators such as leptin, which can accelerate activation of the hypothalamic-pituitary-gonadal axis and contribute to an earlier onset of menarche. Therefore, understanding the relationship between nutritional status and early menarche is important not only from a clinical perspective but also as a public health concern affecting adolescent reproductive health outcomes.

In addition to these epidemiological trends, several factors are known to influence the age of menarche, including genetic predisposition, nutritional status, social environment, media exposure, and lifestyle (Lee et al., 2016). Nutritional status is a condition that reflects the balance between nutrients absorbed by the body and those used for overall metabolic processes (Mulyani, 2018). In adolescent girls, nutritional status greatly influences the occurrence of menarche, including its triggering factors, the presence of complaints during menstruation, and the duration of menstrual bleeding. Among these factors, nutritional status especially being overweight or obese has often been associated with early menarche, as reflected in a higher Body Mass Index for Age. Several studies have reported a decreasing trend in the age at menarche in various countries, including Indonesia. At SMP Negeri 1 Winong in Central Java, 68.8 percent of female students were reported to have experienced early menarche (Kholifah, 2024). Another study at SDN Kertajaya 4 and 9 in Surabaya found that 26.9 percent of female students experienced early menarche, with the majority being eleven years old, followed by ten years old at 35.9 percent, and some as young as nine years old at 5.1 percent (Rosiardani, 2018).

Early menarche can have various physical, psychological, and social consequences. Physically, adolescents who experience early menarche tend to reach a shorter final height and have a higher risk of health issues such as high cholesterol levels, cardiovascular diseases, and early menopause (Khuzaiyah et al., 2024). Early puberty is also linked to an increased risk of breast cancer due to prolonged exposure of breast tissue to carcinogenic factors such as chemicals, estrogen, and radiation (Ade et al., 2025). According to Diana (Diana et al., 2023), adolescents with early menarche are 2.87 times more likely to experience dysmenorrhea compared to those who reach menarche at a normal age. A study in Taiwan involving 775 breast cancer patients showed that age at menarche significantly influenced the risk of early onset breast cancer before the age of forty (Yang et al., 2022). Psychologically, early menarche is associated with an increased risk of depression, anxiety, and emotional distress (Khuzaiyah et al., 2024). Socially, girls who experience early menarche are more likely to become pregnant at a young age, which

can negatively impact their education, career prospects, and overall well-being in the future (Khuzaiyah et al., 2024) This narrative review aims to explore the relationship between nutritional status and the incidence of early menarche in adolescent girls.

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METHODS

This narrative review was conducted to explore and synthesize recent scientific evidence on the relationship between nutritional status and early menarche among adolescent girls. The literature search was conducted in May 2025 through three major academic databases, namely PubMed, Google Scholar, and ScienceDirect. The search was restricted to peer-reviewed journal articles published between 2015 and 2025 and written in English. To ensure a comprehensive retrieval of relevant studies, various combinations of keywords were used, including “early menarche”, “nutritional status”, “body mass index (BMI) and menarche”, “adolescent girls”, and “adolescent reproductive health”.

Articles were included in the review if they met the following criteria: published within the last ten years (2015–2025), written in English, focused on female adolescents aged 10–19 years, and examined the relationship between nutritional status (e.g., BMI, dietary intake, undernutrition or overnutrition) and the timing of menarche. Only empirical studies with designs such as cross-sectional or case-control were considered. Articles were excluded if they did not specifically address the relationship between nutrition and menarche, if they focused on populations outside adolescent girls, or if they were case reports, commentaries, editorials, or lacked sufficient data for analysis.

he initial literature search identified 1,414 articles across PubMed, Google Scholar, and ScienceDirect databases. Duplicate records were removed prior to screening. The remaining articles were screened based on titles and abstracts to assess their relevance to the review objective. Studies that did not investigate the relationship between nutritional status and age at menarche, involved populations other than adolescent girls, or did not meet the inclusion criteria were excluded. Subsequently, full-text assessment was conducted to evaluate eligibility and methodological relevance. After applying all inclusion and exclusion criteria, five studies were retained for the final review and synthesis. The literature selection process followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, and the detailed study selection process is presented in Figure 1.

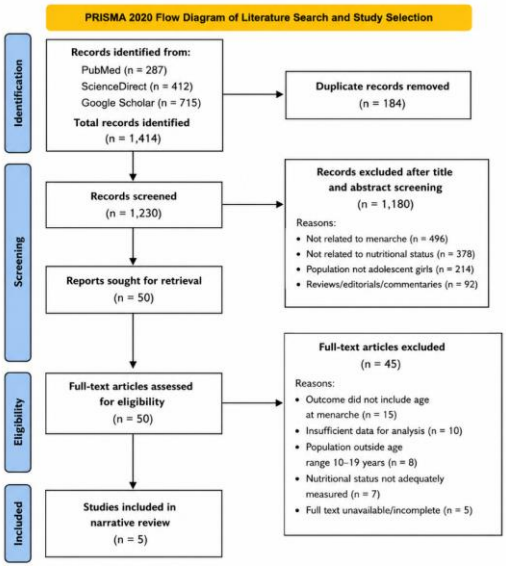

Figure 1. PRISMA 2020 Flow Diagram of Literature Search and Study Selection.

Methodological quality assessment was conducted using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies, a standardized tool commonly used to evaluate the methodological quality and risk of bias in observational studies. The checklist assesses several domains, including the clarity of inclusion criteria, validity and reliability of exposure and outcome measurements, identification of confounding factors, strategies to address confounding variables, and appropriateness of statistical analyses. Only studies that met the methodological quality criteria were included in the final review. Following quality assessment, data were extracted from the selected studies, focusing on study characteristics, nutritional status indicators, age at menarche, and key findings regarding the association between nutritional status and early menarche. The extracted data were subsequently synthesized narratively. Similar findings were grouped into thematic categories, while differences among studies were analyzed to identify potential contextual factors influencing the observed relationships.

FINDINGS

Author, Years	Tittle	Participants	Aims	Type of study, methods	Result
(Barros et al., 2019)	ERICA: age at menarche and its association with nutritional status	40,803 Brazilian girls (12–17 years)	To estimate mean age at menarche and its association with BMI	Cross-sectional, ERICA study, Cox regression	Overweight and obesity linked to earlier menarche (HR=1.28, p<0.001)
(Oliveira et al., 2024)	Nutritional status and age at menarche in Amazonian students	1,017 girls (6–17 y), Manaus	To assess menarche age related to BMI, ethnicity, SES	Cross-sectional, recall & status quo methods	Obese girls had earlier menarche (11.4 y) vs normal (12 y) and lean (12.7 y)
(Dwi Anggraini et al., 2023)	The Correlation between Nutritional Status and Age of Menarche among Adolescent Students	39 girls (grades 4–6), Indonesia	To examine the relationship between nutritional status and menarche	Cross-sectional, Spearman's rho test	Significant association between BMI and menarche age (p=0.001)
(Yani et al., 2023)	The relationship between menarche and nutritional status in Junior High School students in Aceh Besar. A study from 30 years of armed conflict area, Aceh, Indonesia	278 junior high girls, Aceh	To explore menarche-nutritional status link in post-conflict area	Cross-sectional, Chi-square test	Significant association (p<0.05); 79.1% normal menarche, 64.7% normal nutrition
(Hartati & Irmawati, 2024)	The Relationship Between Nutrional Status And Event Early Menarche In Children Aged 9-12 Years	63 girls (9–12 y), Central Java	To determine link between nutritional status and early menarche	Cross-sectional, anthropometry, Spearman test	Overweight associated with early menarche (p=0.003)

The literature review identified five eligible studies published between 2019 and 2024 that examined the relationship between nutritional status and age at menarche among girls and adolescents. Two studies were conducted in Brazil (Barros et al., 2019; Oliveira et al., 2024), while three studies were conducted in Indonesia (Dwi Anggraini et al., 2023; Yani et al., 2023; Hartati & Irmawati, 2024). All included studies employed a cross-sectional design, although they differed in sample size, study setting, and statistical approaches. The number of participants ranged from 39 to 40,803 girls, covering various age groups from late childhood to adolescence. Nutritional status was generally assessed using anthropometric indicators, particularly body mass index (BMI), while age at menarche was measured through self-reported menstrual history.

Overall, the findings consistently demonstrated a significant association between nutritional status and the timing of menarche. Four studies reported that girls with overweight or obesity tended to experience menarche at a younger age than girls with normal or lower nutritional status. The largest study, conducted by Barros et al. (2019) in Brazil, found a significant association between excess body weight and earlier menarche (HR = 1.28; $p < 0.001$). Similar results were observed in both Brazilian and Indonesian populations, where higher BMI was associated with an increased likelihood of early menarche. Although differences in population characteristics and analytical methods were evident across studies, the overall pattern indicated that excess nutritional status was consistently related to earlier pubertal development among adolescent girls.

DISCUSSION

Several studies have demonstrated a significant association between nutritional status and the timing of menarche in adolescent girls. Overweight and obesity are consistently linked to earlier menarche, while undernutrition is associated with delayed onset of puberty. The ERICA study conducted in Brazil by Barros et al. (2019) found that adolescent girls with excess weight reached menarche at a younger age compared to their peers with normal or low weight. Multivariate analysis indicated that excess weight was significantly associated with early menarche (HR equals 1.28; 95 percent CI: 1.21 to 1.36; p less than 0.001), even after controlling for sociodemographic factors.

Similarly, Oliveira et al. (2024) reported that overweight and obese girls in the Amazon region experienced menarche earlier than their normal weight and lean peers, regardless of race or socioeconomic status. Notably, girls who experienced menarche before age twelve were found to have slightly shorter predicted adult heights, suggesting possible disruption in growth duration.

In Indonesia, Dwi Anggraini et al. (2023) observed a statistically significant relationship between nutritional status and age at menarche (p equals 0.001) among elementary school students. The majority of girls with normal nutritional status reached menarche at the expected age range of eleven to thirteen years, whereas those with overweight or obesity were more likely to experience early menarche. Yani et al. (2023) further confirmed these findings in a postconflict setting in Aceh, where nutritional status remained a significant determinant of menarche despite widespread food insecurity and limited health services. Girls with normal nutritional status were more likely to reach menarche at a normative age compared to undernourished peers (p less than 0.05).

Supporting these national and international findings, Hartati and Irmawati (2024) conducted a cross-sectional study involving 63 girls aged 9–12 years at SD Negeri Karangawen 1 in Demak Regency. Their study found that 92.1% of the respondents experienced menarche before the age of 12, and most had an overweight nutritional status (57.1%). A significant negative correlation was found between nutritional status and age at menarche (Spearman's rho = -0.364; $p = 0.003$), indicating that higher nutritional status is associated with an earlier onset of menarche.

The physiological mechanism that links excess adiposity to early menarche is primarily mediated by the hypothalamic pituitary gonadal axis. The onset of puberty begins with the reactivation of the gonadotropin releasing hormone pulse generator in the hypothalamus, which stimulates the anterior pituitary to release luteinizing hormone and follicle stimulating hormone. These gonadotropins act on the ovaries to produce estrogen, resulting in follicular development and ultimately menarche. This intricate hormonal cascade is regulated by upstream neuromodulators such as kisspeptin, neurokinin B, and dynorphin, collectively known as the KNDy neuronal network. Kisspeptin, in particular, is a key stimulator of gonadotropin releasing hormone and a critical initiator of puberty.

Nutritional signals, especially leptin, play an important role in modulating this neuroendocrine system. Leptin levels rise with increased adiposity and act as a permissive signal indicating that the body has sufficient energy reserves to support reproduction. In both animal and human studies, leptin has been shown to stimulate kisspeptin expression, thereby activating gonadotropin releasing hormone secretion. Conversely, undernutrition or leptin deficiency suppresses this pathway and delays pubertal onset. This mechanism explains why girls with excess weight often experience earlier activation of the hypothalamic pituitary gonadal axis and earlier menarche.

In addition to central mechanisms, adipose tissue functions as an active endocrine organ that can convert androgens into estrogens through the action of the aromatase enzyme. This peripheral source of estrogen may promote early endometrial proliferation and menstruation independently of central hypothalamic activation. Therefore, both central neuroendocrine and peripheral adipose derived pathways may act synergistically to accelerate menarche in girls with excess body fat.

LIMITATIONS

Limitation of Studies Reviewed

All studies included in this review utilized a cross sectional design. This limits the ability to establish a causal relationship between nutritional status and early menarche. While the association is evident, it is not possible to confirm whether increased body mass index preceded the onset of menarche or occurred as a result of early pubertal development.

The reliance on body mass index as the main measure of nutritional status presents another limitation. Body mass index does not distinguish between fat mass and lean mass and does not account for fat distribution or underlying metabolic health. As such, it may not fully capture the complexity of how nutritional status influences the timing of menarche.

Additionally, several potentially influential confounding variables were not consistently measured across studies. These include dietary intake, levels of physical activity, genetic predisposition, and psychosocial stress. The absence of these variables limits the understanding of the multifactorial nature of pubertal development.

Limitation of the Review Methodology

This narrative review may be affected by selection bias. The included studies were limited to published cross sectional research from Brazil and Indonesia. As a result, the findings may not be fully generalizable to other populations or regions with different socioeconomic or cultural contexts.

The lack of inclusion of longitudinal studies or grey literature may have excluded relevant data that could provide additional insights. Furthermore, the review did not employ a systematic selection process, which increases the potential for missing studies that may have yielded contrasting results.

To strengthen future research, a broader range of study designs and geographical contexts should be included. Longitudinal studies in particular would be valuable in clarifying the temporal sequence between weight gain and menarche and in identifying additional modifiable risk factors.

CONCLUSIONS AND RECOMMENDATIONS

This narrative review highlights a consistent and significant association between nutritional status, particularly overweight and obesity, and early menarche among adolescent girls. Across diverse populations in Brazil and Indonesia, girls with higher

body mass index are more likely to experience menarche at an earlier age compared to their peers with normal nutritional status. The biological mechanism underlying this relationship is most likely mediated by increased adiposity influencing hormonal pathways, such as elevated leptin levels stimulating earlier activation of the hypothalamic–pituitary–gonadal axis. Early menarche has important health and psychosocial implications, including increased risks of metabolic diseases, reproductive health problems, and emotional challenges. Given the rising global prevalence of childhood overweight and obesity, these findings underscore the urgent need for public health interventions aimed at promoting healthy nutritional status to support normal pubertal development and prevent adverse long-term outcomes. Schools and community health services should implement targeted nutrition education programs focusing on balanced diets and healthy body weight, while also encouraging regular physical activity among children and adolescents. Healthcare providers are advised to routinely monitor nutritional status and pubertal development to identify girls at risk of early menarche and provide timely counseling. Moreover, policymakers should integrate obesity prevention strategies within adolescent reproductive health programs to address the multifactorial causes and consequences of early menarche. Future research employing longitudinal designs is necessary to better understand causal pathways, including the roles of diet quality, physical activity, psychosocial factors, and genetic predispositions. Finally, raising awareness among parents and caregivers about the impact of nutrition and lifestyle on puberty timing is crucial to empower families in supporting healthier habits for children

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